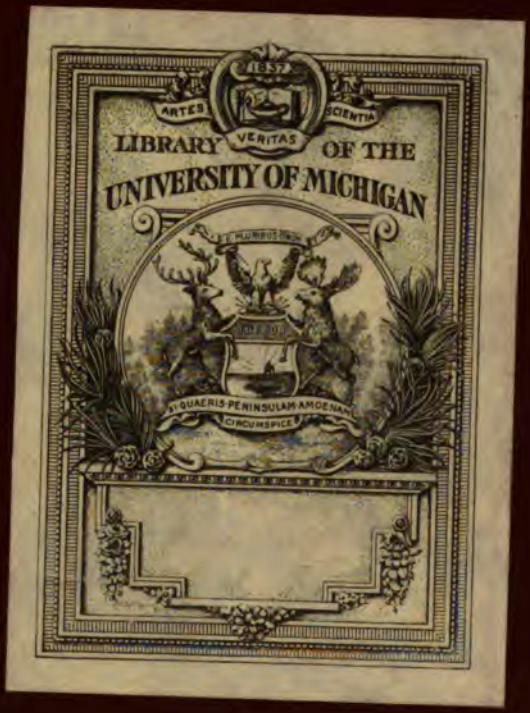

A MANUAL

OF

ELECTRO-THERAPEUTICS

FOR

Students and General Practitioners

BY

C. T. HOOD, A.M., M.D.

MEMBER OF THE AMERICAN SOCIETY OF ELECTRO-THERAPEUTICS

CHICAGO

GROSS & DELBRIDGE COMPANY

1895

TO

N. B. DELAMATER, A. M., M. D.

AS A VERY SLIGHT TOKEN OF THE HIGH ESTEEM IN WHICH HE IS HELD AS A MAN, A PHYSICIAN, AND A CLINICAL TEACHER, THIS LITTLE WORK IS RESPECTFULLY DEDICATED BY

THE AUTHOR

PREFACE.

This Manual on Electro-Therapeutics has been prepared at the request of many students and practitioners who desire something on this subject that shall be concise and easily understood. I have undertaken to make the Physics as complete as the necessities of the general practitioner demand, and so simple that a previous scientific training is not necessary to its comprehension. I have freely used in the preparation of this Manual every book published on Electro-Therapeutics.

To Leverne Wheeler, of this city, I am indebted for the drawings from which the cuts have been made.

C. T. HOOD, M. D.

31 WASHINGTON STREET
CHICAGO

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INTRODUCTION.

Electricity is one of the most useful and most abused of all the remedies at the command of the modern physician. It has been used by the good physician as well as the charlatan; and the good physician has in many instances discarded it, because he did not obtain from it the results he expected.

But why did he not obtain the desired results? Would you trust your watch for repairs to a man who knew that a watch had a main-spring, a hair-spring and wheels, but who knew nothing of the relative positions of these parts, nor their perfect construction? Would you care to trust your life or the life of your child or friend to the care of a man who knew that aconite might kill and that arsenic was a poison; but as to the dose of aconite or its physiological action he knew absolutely nothing; nor did he know the effect of any drug upon the human body?

How then can we expect a physician to obtain such results, be he ever so kind, gentle and patient, yet knowing nothing of electricity beyond the fact that in some way or other, from his battery, he obtains what he calls electricity; that upon his battery is marked positive and negative; that some one in some book or journal has advised the use of electricity in certain diseases, claiming for it good results?

As has been previously said, electricity is one of the most useful of all the remedies at the command of the modern physician, because it is applicable in a large class of troubles, and will reach conditions that drugs will not touch.

If it be true that electricity is such a wonderful agent, it must of necessity demand careful study and consideration. In the very beginning let me impress this fact upon you; electricity is

not a "cure-all" for all the aches and ailments to which the human body is heir, but a most potent agent, and one from which most satisfactory results can be obtained when used by the intelligent physician who understands its action and dosage as he understands the action and dosage of any other remedy.

It is to teach the intelligent use of electricity that this Manual is prepared.

I propose to consider:

1. What electricity is so far as known.
2. The methods of obtaining it.
3. The construction and care of a battery.
4. The physical and therapeutical use of the current.
5. Its use in surgery, or the cautery.

Many of my readers will understand the physics of electricity. Others will have a vague idea of its physics; while some will know nothing of it.

As we study physiology before pathology, anatomy before surgery, physiological action before therapeutical effect, we will make no exception in the study of this remedy.

Underscore in your mind that word *remedy*. Do not call it by any other name. Do not attempt to study it in any way different from that of the study of any other remedy.

It is not expected that in this brief Manual which includes physics, electro-physiology, electro-therapeutics and electro-surgery, that an extensive study of the physics of electricity can be contemplated.

In all the works on electro-therapeutics that I have seen, the physics have been so extensive, elaborate, unsatisfactory and complicated, that the student and busy practitioner begin the study of electro-therapeutics at once, and hence do not understand it.

We shall endeavor in our work to study the physics of electricity; its laws; and observe its wonderful phenomena in the simplest way possible; trying, as far as practicable, to illustrate the facts demonstrated, by means that may be at the command of every one, so that you can verify them.

In this perfect universe of ours all things have their behavior

as the result of some Law. The myriads of fixed stars, the movements of the planets, the flash of the glowing meteor, the growth and expansion into perfect foliage of the plant, the dropping of the leaves, the growth and development of man; these all behave in a certain way under certain circumstances.

The behavior of anything is the result of a Law. The manner of the behavior shows what the Law is. To illustrate, let us take the Law of gravity.

If I hold in my hand a book and move my hand up or down, the book goes with it; if I remove my hand, the book falls. Try it again and again; no matter how carefully, or how slowly the hand is removed, the book falls.

Let us take a feather. We open the window, putting the feather on the hand. Away it goes, over the street and the house tops, floating far away; is this an exception to the rule? Does the Law not work here? Will not the feather fall? Try again, with another feather. The windows and doors are closed, the air is still. Drop the feather. It flutters and finally falls to the floor. But why did not the feather thrown out of the window fall. Simply because the Law of gravity was overcome for the time by a stronger Law in its relation to the feather, viz: atmospheric pressure.

These are experiments. What is an experiment? It is asking of nature the question, why under certain circumstances certain things happen?

Experiments teach us Laws. By experimenting almost all great things have been discovered. It was experimenting that enabled Newton to discover this Law of gravity. It was experimenting that formed the science of chemistry. It was experimenting that enabled William Harvey to discover the circulation of the blood, and it was by experiment that Franklin discovered the identity of electricity.

In electricity there is yet a vast work to do. We are but at the gateway, and beyond us lies a wonderful undiscovered country.

In medicine the use of electricity has only begun. In this

department there is plenty to do, and any one may make himself famous in it.

The experiments to which I shall call attention will be in electricity, and they will be as simple as it is possible to make them.

A MANUAL OF ELECTRO-THERAPEUTICS.

CHAPTER I.

How to Obtain Electricity by Friction.

Take an egg-glass and an egg (Fig. 1), place the egg in the glass large end down and then place the center of a pine stick which is eighteen inches long, one-fourth of an inch thick and one inch wide, upon the small end of the egg and you will see that it balances. Now if you touch it with your finger it spins around. This is an experiment; a mechanical experiment.

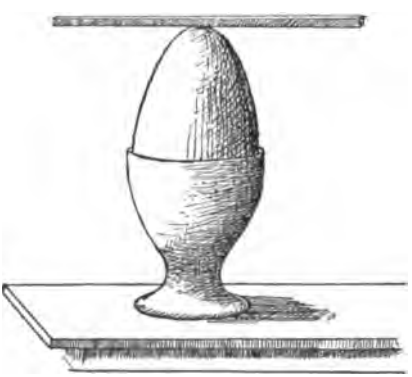

FIG. 1.

Take a little baking soda and some vinegar, put the two together and some kind of a commotion occurs. Take some pieces of zinc, put them in a glass, pour a little water on them and add to it a small quantity of hydrochloric acid and a commotion takes place. These are chemical experiments.

We might go on making experiments in light, heat and sound, but we have shown you enough to illustrate what is meant by an experiment.

For electrical experiments, the best time is in the evening, in a cold room with a dry atmosphere. Everything used in electrical experiments must be warm and thoroughly dry.

Take a heavy glass tube an inch in diameter, eighteen inches long, and have a silk pad six inches square. (Fig. 2.) Put on the table some silk ravelings, some tiny bits of gold and some tufts of cotton. Lay the tube down upon the ravelings, gold and cotton. Lift up the tube and lay it down again; there is no result, no sound, no heat, no light, no change in the relative positions of the cotton, gold or ravelings, nor in their relation to the tube.

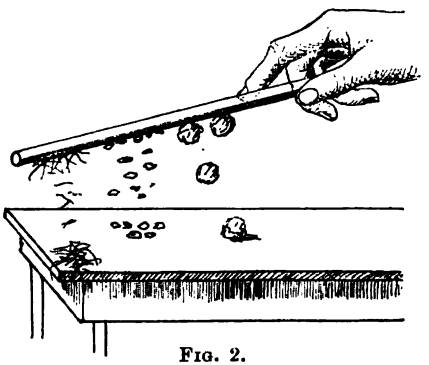

FIG. 2.

Try again; hold the tube over the gas jet until it is thoroughly warm and dry, and also hold the silk pad near the gas jet until it is thoroughly warmed and dried. Now rub the tube briskly with the silk and bring it near the ravelings, gold and cotton, and instantly a change takes place; the ravelings fly up to meet the tube, the bits of gold line themselves side by side upon the tube, and the tufts of cotton vie with each other in their haste to reach it.

Watch them as one by one they loosen and fall again to the table until they are all off. Bring the tube nearer and again they fly to it. Watch them and slowly they drop off one by one. Pass the tube through your hand and bring it near the silk, gold and cotton, but no result is obtained. Rub it again and you will observe the same results as before. The phenomenon which we observed was due to the friction of the silk upon the glass.

Take a glass tumbler and turn it bottom-side up, and place on the top the tied end of a tassel made of silk threads, and place upon this end a penknife. (Fig. 3.) Warm the glass tube, bring it near the tassel and touch the tassel with it, but there is no result, no effect. Again rub the tube with the warm silk pad and bring it near the tassel; you will observe before the tube has reached within a foot of the tassel each thread stands straight up and separates itself from its fellows. Take the tube away and touch your finger to the tassel and it collapses as it was at first.

Bringing the tube to it again and again, the same phenomenon is observed, but if you rub the tube through your hand and again bring it to the tassel, there will be no phenomenon. This phenomenon is due to what we call electricity which has been set free on the tube by the friction with the silk.

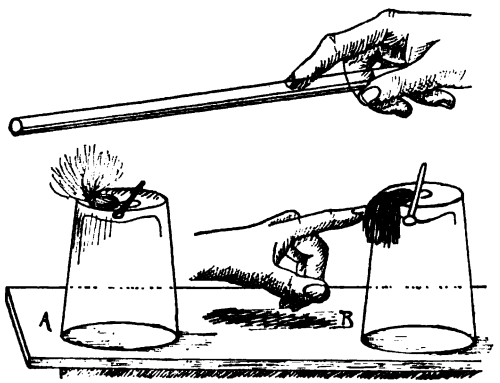

FIG. 3.

Balance the pine stick upon the egg, as in the mechanical experiment, bring the tube near the stick, and unless you touch the stick with the tube there is no result; try it above or below, still there is no result. Rub the tube with the warm silk and bring it near the stick. When several inches away from the tube you will see the stick begin to waver. The end over which the tube is rises up; put the tube underneath it and it comes down; put the tube to the side, and the stick follows it around. (Fig. 4.)

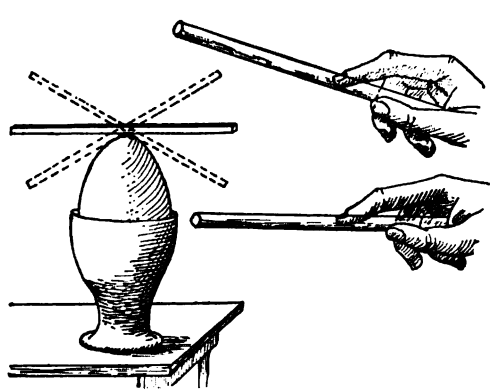

FIG. 4.

Note that the results are only obtained when the tube has been rubbed by the silk and before it has come in contact with the hands. Wait a little and bring the tube to the stick again and the same phenomenon occurs, but not so pronounced. Wait a few minutes longer and it has disappeared. Whatever it was, it was due to friction. It was electricity.

This phenomenon has never been and probably never will be explained. The rubbing of the tube with the silk sets free what we call electricity, and the free electricity attracts the silk ravelings, the gold, the tufts of cotton, the silk tassel and the balanced stick. Attraction is a property of electricity.

CHAPTER II.

The Electroscope—Conduction.

Take a glass bottle two and one-half inches in diameter and six inches in depth, and a piece of wood three inches long, three-fourths of an inch wide and one-fourth of an inch in thickness with a small hole in its center. Take a piece of soft copper wire, one end of which you twist into a ball, the other end you pass through the small hole in the bit of wood; then bend half an inch of the end of the wire at right angles to the long piece. Drop this piece of wire into the bottle; the piece of wood fitting across the mouth of the bottle allows the end of the wire which is in the bottle to come within an inch and a half of the bottom of the bottle and leaves two inches and a half of wire (with the ball of wire on its end) above the piece of wood. (Fig. 5.)

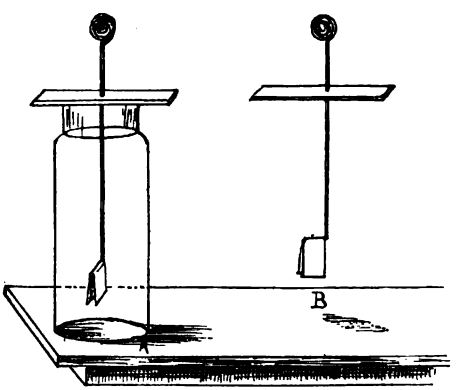

FIG. 5.

Take a piece of gold foil (such as dentists use for filling teeth) one-fourth of an inch in width and three inches long. Taking hold of the stick lift the wire out of the bottle and over the bent end suspend the piece of gold foil by its center. Now put the wire in the bottle with the piece of wood resting across the mouth. Take a glass tube and a silk pad, hold them over the gas jet until they are thoroughly warmed and dried. Bring the

glass tube near the wire ball; you may even touch the wire ball with the glass tube but there is no result. Now rub the glass tube with the silk pad and as soon as you bring the tube within two or three inches of the wire ball you see a phenomenon: the ends of the gold foil separate and stand out at right angles to each other. Take the tube away and they soon drop together. (Fig. 6.) Repeating the experiment again and again, you obtain the same results.

Now bring the glass tube after it has been rubbed with the silk close to the wire ball; the ends of the leaf fly apart Still holding the tube in the same position touch the wire ball with the finger of the other hand, the ends of the foil drop together and then instantly stand apart. Repeat the experiment and you obtain the same results.

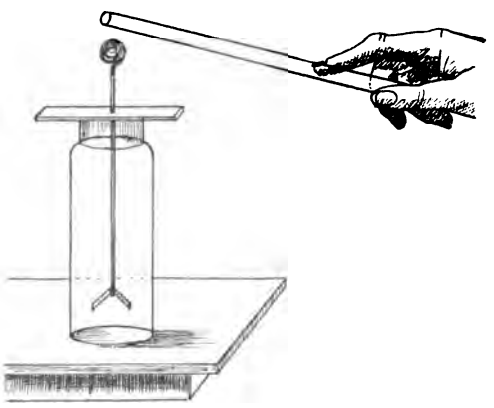

FIG. 6.

We call this instrument an electroscope. We know from past experience that by rubbing the glass tube with a silk pad electricity is set free. We observed when the tube (before it had been rubbed) was brought near, or even touched the wire ball, there was no result; but after being rubbed every time it was brought near or touched the wire ball the ends of the foil stood apart. We know that it was electricity which produced this phenomenon, and there is nothing else which will produce it.

An electroscope is used to detect the presence of electricity. Whenever free electricity is present in anything and it is brought near the wire ball of the electroscope the ends of the foil stand apart; under no other circumstances will they do this. Why they do this, and the laws governing their actions, we will learn later on.

Leave this for the present and try these experiments:

Rub the tube briskly with the silk and bring it near the tufts of cotton and the bits of gold; instantly they fly up to it, remain a few seconds, drop off and fly back again. Now observe that the free electricity on the tube possesses the power of attraction for these particles of matter; but the tube must be within an inch and a half or two inches of the cotton or the foil before they are attracted.

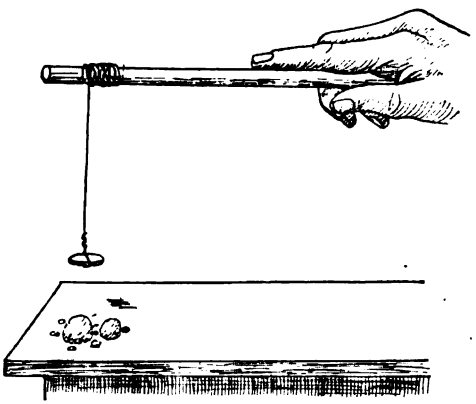

FIG. 7.

Take a piece of copper wire eighteen inches long, twist one end of it around a copper cent so that when you hold the wire by the other end the flat side of the cent hangs down; twist the other end of the wire around the glass tube, wrapping it snugly and fastening the end. (Fig. 7.)

Hold the tube up so that the cent on the end of the wire is above the cotton and the bits of gold; no result. The cent is allowed to drop upon them, but no result. Now rub the tube briskly and hold it so that the cent hangs just over the tufts of cotton and the bits of gold, and you will see as soon as the cent reaches within an inch and a half or two inches of the table that the cotton and gold fly to it, remain a few seconds and then drop off, only to return again; in fact, presenting the same phenomenon they did with the tube. (Fig. 8.)

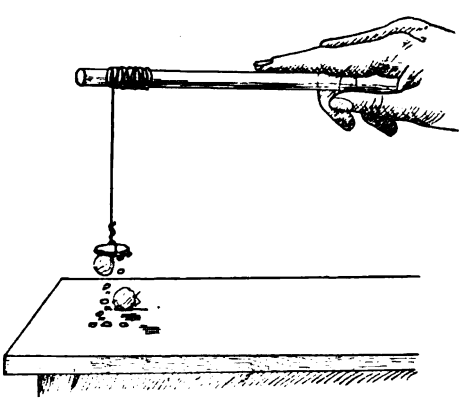

FIG. 8.

We know that the friction of the silk on the glass sets electricity free; we also know that the tube was too far away from the different articles used for the electricity upon it to attract them; yet we observe the same phenomenon we did with the tube and we know that these phenomena are due to the electricity. How are these results brought about? There is only one possible way: The electricity must have passed over the copper wire; or, in other words, it was conducted by the copper wire, and it attracted at the end of the wire; so we have attraction by conduction.

Let us try another experiment: Take a piece of copper wire twenty-four inches long, twist one end of it around the end of the glass tube and the other end around the wire in the electroscope just beneath the ball. Hold the tube up, but there is no result. Now you will remember that when the tube was rubbed and brought within two or three inches of the wire ball the ends of the gold stood apart. Rub the tube and you will observe the same result: The ends of the gold leaf stand apart (Fig. 9.) although the glass tube is twenty-four inches from the electroscope. We know that nothing but electricity will produce this phenomenon. It is fair to say then that electricity has been conducted from the tube by the copper wire to the electroscope.

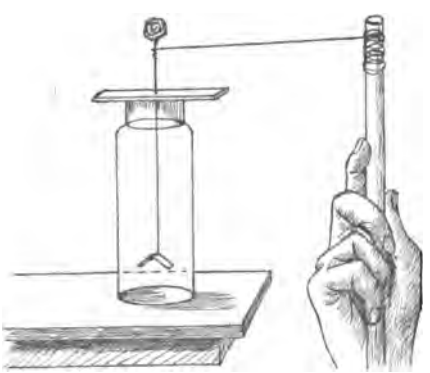

FIG. 9.

So far we have demonstrated by experiment that electricity is set free by friction; that it has the power of attraction; that it can be conducted, and that it has the power of attraction by conduction.

Remember that it is not the tube which attracts, but the free electricity upon it; for as soon as the tube is rubbed through the hands the phenomenon ceases.

These are simple experiments, yet they teach us great laws, and upon them depends every application of electricity.

It is not known who discovered that electricity possessed the power of attraction, but it was first conducted in 1729.

So far in our experiments we have obtained free electricity by the friction of silk upon glass. By experimenting with other materials it is easy to demonstrate that electricity is not confined to glass alone.

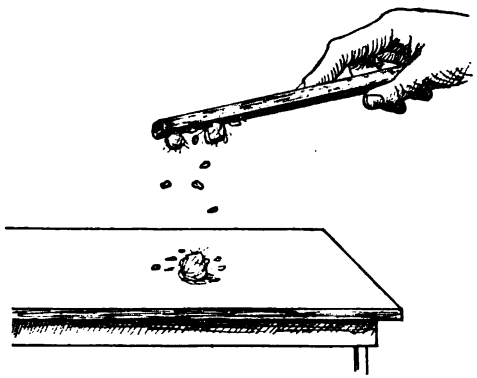

FIG. 10.

Take a piece of sealing-wax similar to that used in sealing cans and a piece of flannel. Rub the sealing-wax with the piece of flannel, bring it near the tufts of cotton and the bits of gold and you will see the same results as you obtained by rubbing the glass tube with the silk. (Fig. 10.)

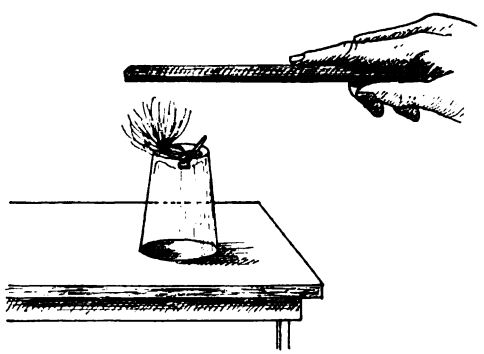

FIG. 11.

Rub the sealing-wax through the hands and bring it near the cotton and gold; no result. Rub it again with the flannel, the cotton and gold are again attracted; bring it near the tassel and each fibre stands out separately. (Fig. 11.)

We know from past experience that these phenomena are due to electricity alone; and you have been shown that electricity can be set free by the friction of flannel upon sealing-wax.

Procure a piece of hard rubber one-half inch in diameter and eighteen inches long; bring it near the cotton and gold; no result. Rub it with the flannel and you will observe it is highly

electrical. (Fig. 12A.) Bring it near the electroscope and the ends of the gold-leaf fly apart. (Fig. 12B.)

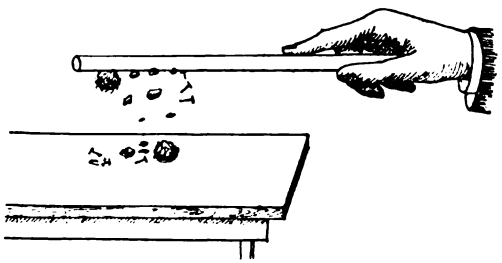

FIG. 12A.

You have demonstrated that electricity can be set free by the friction of flannel upon hard rubber.

Take some pieces of ordinary-sized blotting paper, and turn down the opposite corners of one piece, and lay it on top of another piece. Lift it up by the corners; no result. Rub the under piece with the flannel cloth and lay the other one upon it; lift by the corners and you will find the two are stuck together. Watch it a moment and the lower one will drop off. (Fig. 13.)

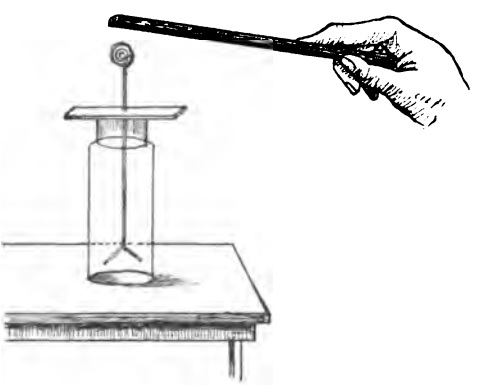

FIG. 12B.

This is the result of electricity set free by the friction of the flannel upon the blotting-paper. So we might continue demonstrating by experiment the presence of electricity in many things.

Although it has not been proven here, yet a sufficient number of experiments have been made to show that electricity exists in all things in a latent condition, and that when we disturb its equilibrium by friction or otherwise it becomes manifest by these various phenomena.

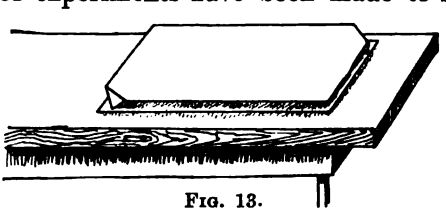

FIG. 13.

So far in our experiments we have set electricity free by friction, and from that fact it is called frictional or static electricity.

By previous experiments we know that electricity can be conducted by copper wire, therefore copper wire is a conductor of electricity. By experiment it has been learned that other things conduct electricity.

Take a piece of iron wire and use it in a similar manner to the copper wire and you will find you can obtain the same results.

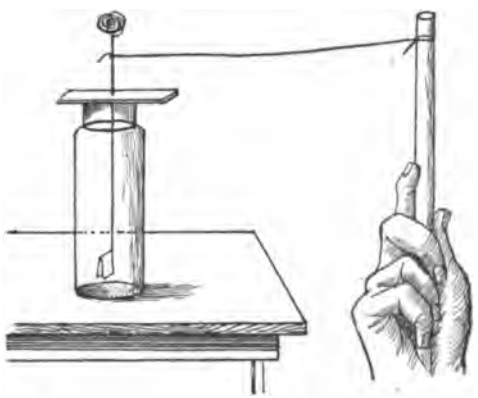

Fig. 14.

Try the same experiments with steel wire and the results are the same. Try it with a cotton thread, still the same result, only not so well marked. Try a silk thread; rub the glass tube as hard as possible with the silk pad and you will obtain no result. (Fig. 14.)

Take a piece of glass tubing one-eighth of an inch in diameter and three inches long; around one end of it twist a piece of copper wire ten inches long; the other end of the wire is twisted around the large glass tube. Around the other end of the small glass tube twist a similar piece of copper wire and twist its free end around the wire of the electroscope. We know that the copper wire is a conductor of electricity. Rub the glass tube as hard as possible with the silk pad, but no result follows. (Fig. 15.) Take the copper

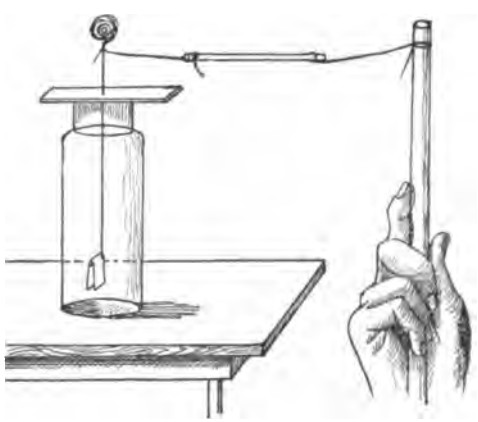

Fig. 15.

wire off the small glass tube, twist its ends together and then rub the large tube; the ends of the gold-leaf fly apart.

What have you learned? That a number of things will conduct electricity and that silk and glass will not conduct it; and you say that copper is a conductor and glass and silk are non-conductors.

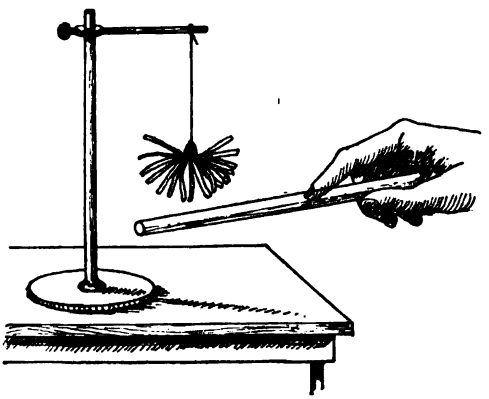

FIG. 16.

Try the silk thread again. Rub the tube as hard as you may, the electroscope gives no result. Take the silk thread and wet it and try the same experiment, and you do obtain results. What is the difference? The dry silk is a non-conductor, but water is a conductor.

Make a tassel of tissue paper; suspend it by a silk thread; rub the tube and bring it to the tassel and every piece will stand out. (Fig. 16.)

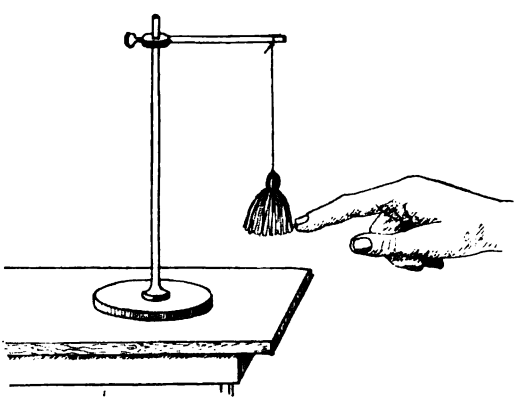

FIG. 17.

Touch the tassel with the finger and it collapses. (Fig. 17.) Repeat the experiment and you will obtain the same result. Suspending the tassel by a copper wire, rub the tube and bring it to the tassel; no result. In the first experiment the silk thread was a non-conductor, and the electricity was stored in the tassel; touching it with the finger caused the electricity to escape over the finger, and the tassel collapsed. In the second

experiment the copper wire was a conductor and the electricity escaped over the copper wire as rapidly as it entered the tassel.

Try another experiment. Take four feet of copper wire; fasten one end to the electroscope and the other end to the glass tube; (this wire must be suspended by copper wires from retort stands). Rubbing the glass as hard as possible produces no result. (Fig. 18.)

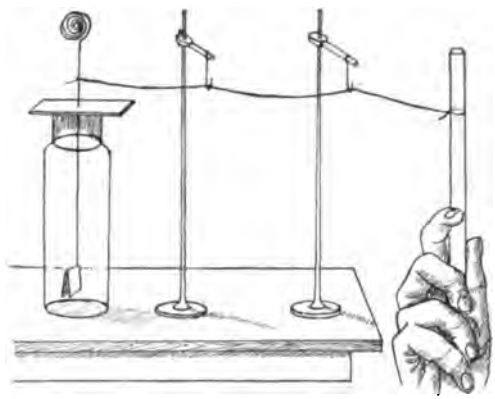

FIG. 18.

Change it a little. Untwisting the wire from the electroscope and unfastening the copper wire loops, slip the copper wire through small glass rings which are suspended by copper wire; fasten the wire again to the electroscope, rub the tube and the leaf in the electroscope indicates the presence of electricity. What have we proven? That electricity may be conducted over a conductor for some distance, providing the conductor does not rest upon conductors, as the copper wire; but upon non-conductors, as the glass rings. These glass rings are what electricians call insulators. They prevent the escape of electricity. (Fig. 19.) Many things possess this property, such as glass, porcelain, rubber, paraffin, etc., etc.

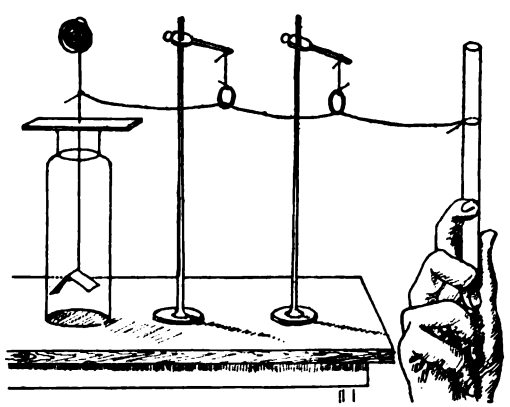

FIG. 19.

The great Atlantic Cable, hundreds of feet beneath the surface of the ocean, is a number of copper wires covered by an insulator.

CHAPTER III.

The Law of Attraction and Repulsion.

If you repeat the experiment with the glass tube and the silk pad, rubbing the tube briskly with the silk and bringing it near the bits of gold, watch closely and you will see the bits fly up to the tube, remain a few seconds and drop to the table, then fly back again and again drop off. They are attracted to the tube by the free electricity, but they fall off; the tube, however, has not lost its power of attraction, for they fly back again.

Here is a phenomenon we have not yet studied; remember this, for we shall return to it.

Let us return to our electroscope. Lift the wire out of the bottle and take the gold foil from the end, lay it on the table and rub the tube with the silk pad, bring it near the foil; it flies to the tube, drops off, and flies again to it. The foil is evidently attracted by the electricity.

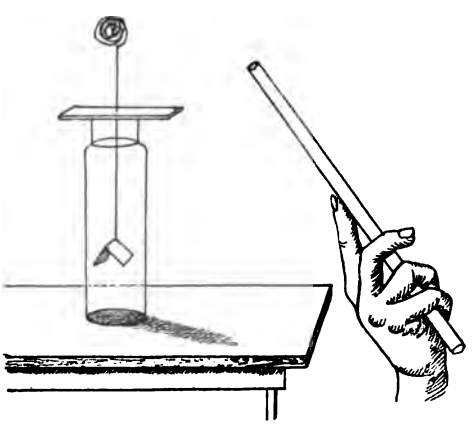

FIG. 20.

Put the foil back on the bent wire and put the wire in the bottle; bring the rubbed tube to the wire ball of the electroscope and the ends of the gold stand apart. (Fig. 20.) We know that electricity is set free by the friction of the silk on the tube; we also know the copper wire will conduct electricity, but why do the ends of the gold-leaf stay apart?

Take a piece of straw one inch long and suspend it by its center from a cotton thread. (Fig. 21.) Rub the tube briskly and bring it to the straw and you will observe that the straw is attracted to the tube; touch it and it drops away, only to return again in a few seconds. Try the same experiment with the sealing-wax and the flannel, and you obtain the same result.

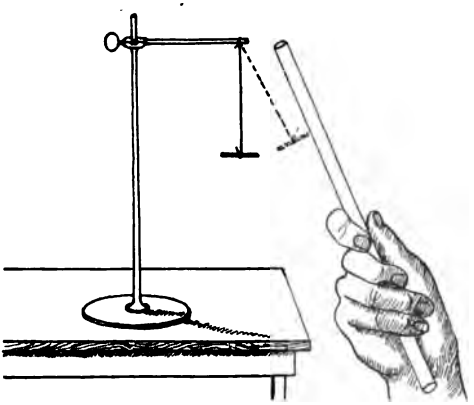

FIG. 21.

Take a similar piece of straw and suspend it by a silk thread. (Fig. 22.) Rub the tube and bring it near the straw; it flies to it, touches it, remains a few seconds and drops away; precisely the same phenomenon you observed with the gold and cotton, and the piece of straw suspended by the cotton thread. But watch it closely and you will find that instead of the straw flying back to the tube it will be impossible to get the tube anywhere near the straw; it stands out in every direction away from the tube. Touch the straw with the finger; instantly it flies again to the tube, remains a few seconds and flies away, and as before will not come near the tube.

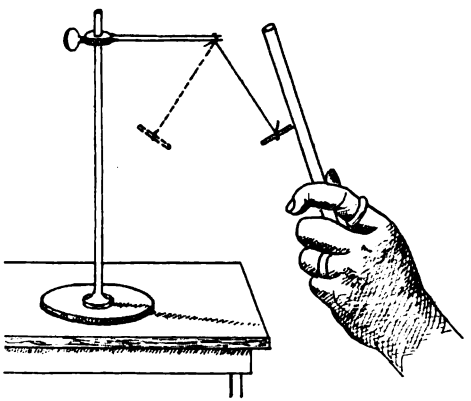

FIG. 22.

Hang another straw by a silk thread from the same point: two bits of straw of the same length hanging side by side. (Fig. 23.) Bring the rubbed tube near them and they will fly to it,

remain a few seconds, fly away and stand out almost at right angles to each other. (Fig. 24.)

Touch the straws with the finger and instantly they will drop together; bring the tube near them again and you will observe the same result.

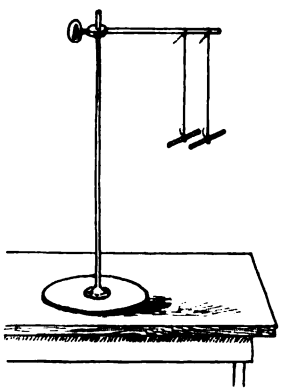

FIG. 23.

This is a curious phenomenon. What does it mean? We know that the friction of the silk on the glass tube sets electricity free, and that electricity possesses the power of attraction. But why does the straw suspended by the cotton thread behave differently from the one suspended by the silk? You know from past experiments that cotton is a conductor of electricity. The straw that is suspended by the cotton thread is attracted to the tube, becomes loaded, or charged as it is called, with electricity and drops away. But as soon as the cotton thread can conduct the electricity away from the straw it is again attracted to the tube. But in the one suspended by the silk thread, the silk being a non-conductor, the electricity remains in the straw and no amount of persuasion on your part will induce the straw to return to the tube until it has discharged its electricity; when you touch it with the finger it is discharged. The two straws obey the same law.

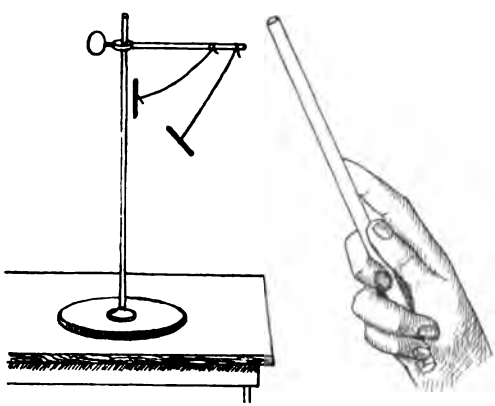

FIG. 24.

The tufts of cotton and the bits of gold fly to the tube, become charged, fly away, or drop off on the table and discharge themselves and then fly back again.

The leaves of the electroscope do the same. What does this teach us? We know that electricity possesses the power of attraction, and we have proven by these experiments that when we load or charge a substance with electricity it is repelled from the tube. Repulsion, then, is a property of electricity. Repeat these experiments, using the sealing-wax and the flannel, and you will obtain the same results.

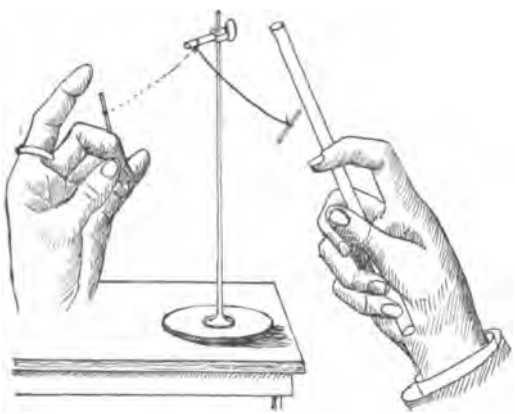

FIG. 25.

Try one more. Rub the tube and bring it to the straw suspended by the silk; it is attracted and then repelled; holding the hand near it, it touches the hand, flies back to the tube, then back to the hand, and then to the tube with the regularity of a clock's pendulum. (Fig. 25.)

The tube attracts it; it becomes charged, is repelled; discharges itself upon the hand; is again attracted and again repelled, and again discharges itself. You see, hear and feel nothing but the results. The straw when discharged is empty of electricity; bring the tube near it and it becomes charged. Charged with the same kind of electricity as is on the tube, but it is now repelled. What does this teach us? That like electricities repel like electricities, or like repels like.

Discharge the straw suspended by the silk thread, and while some one rubs the glass tube with the silk pad, an assistant will rub the sealing-wax with the flannel. Watch closely the results. (Fig. 26.) Bring the glass tube near the straw. It is attracted, then repelled. Touch it and discharge the straw. Repeat the experiment with the same result, discharge the straw by touching it with the finger. Your assistant tries the same experiment with the wax and obtains the same result. He tries again; the same

result. Discharge the straw and hold the tube near it, it is attracted to the tube, then flies away. It is charged with the same kind of electricity as is on the tube: like repels like. But watch it! It flies to the sealing-wax, touches it and flies away. (Fig. 27.)

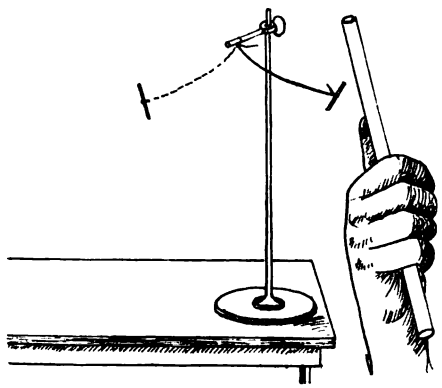

FIG. 26.

Bring the tube near it and it flies again to the tube. It is attracted by both the glass tube and the sealing-wax and is repelled by both. What does this teach us? If like repels like, which we have proven to be true, we have then two kinds of electricity: one on the glass tube, and one on the sealing-wax.

Observe one other thing: the straw is attracted to the tube, then repelled. We know there is another kind of electricity on the sealing-wax, and the straw flies immediately to the sealing-wax. What does this teach us? That like electricities repel, and unlike electricities attract.

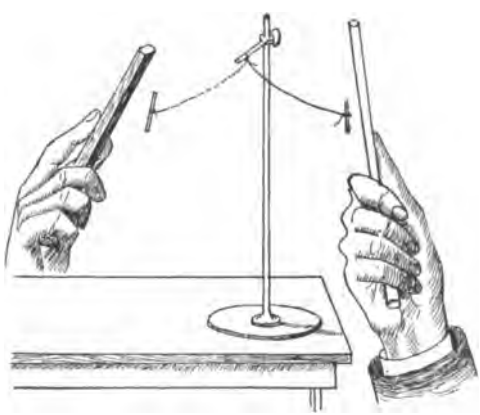

FIG. 27.

It was the same law of repulsion which caused the cotton and bits of gold to fly to the tube, then drop off. It was the same law of repulsion that caused the ends of the leaf of the electroscope to fall apart.

These are simple experiments: they have taught us the law that like repels and unlike attracts. Upon this law depends the movements of the sun, moon, stars and all the other planets; the wonderful application of electricity as made manifest by the telegraph, the telephone, the electric light, the electric motor; the construction of the simplest as well as the most complex electrical instrument.

CHAPTER IV.

Positive and Negative Electricity—Induction.

In the last chapter, we demonstrated that there was one kind of electricity upon the rubbed glass tube and another kind upon the rubbed sealing-wax; that each possessed the power of attraction; that the straw suspended by the silk thread was attracted to each, became charged and was repelled.

Go a little further in this experiment. Warming the glass tube and the silk pad thoroughly, bring the tube to the straw suspended by the silk thread, but no result follows; bring the pad to the straw, still no result. Now rub the tube briskly with the silk pad and bring the tube to the straw; the straw is attracted, flies to the tube, becomes charged or, as it is sometimes called, polarized, and no amount of persuasion will bring the straw near the tube. Touch the straw with the finger and it is discharged. Bring the pad near the straw and you will observe that the straw is instantly attracted to the pad, remains a few seconds and is repelled. (Fig. 28.)

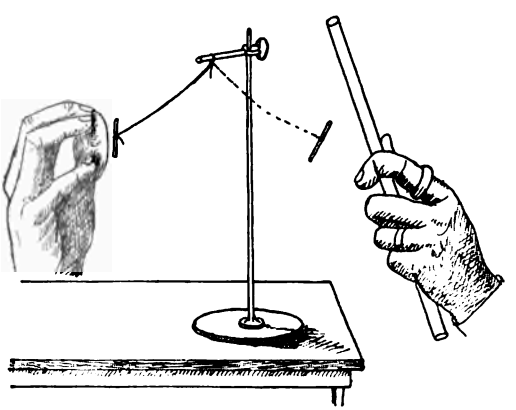

FIG. 28.

What does this mean? Has the pad taken the electricity from

the tube? Discharge the straw with the finger; bring the tube near it, and you will observe the same phenomenon as before.

Nothing but electricity will give these results; therefore there is electricity upon both the tube and the pad.

The straw being discharged, rub the tube briskly with the silk and bring it near the straw; the straw is attracted, charged and repelled; bring the pad near the straw and observe that it is not repelled, but is attracted to the pad; it remains a few seconds and is repelled from the pad.

Bring the tube near it again, and in place of being repelled as before, it is attracted, remains a second, is repelled and flies back to the silk.

If our law of attraction is true, that like repels and unlike attracts, there being electricity upon the tube and upon the silk—we know they must be of different kinds. Such is the fact: the friction of the silk upon the tube sets free two kinds of electricity: that which is on the tube we call positive, and that upon the silk, negative. The reason for calling that on the glass tube positive, is because its property of attraction was first discovered. Long after its discovery, and after it was found to possess the property of repulsion, electricity was discovered upon the pad. The electricity upon the silk pad was found to attract bodies that had been charged with positive electricity; it was the opposite of positive and therefore was called negative.

Repeat these experiments with the wax and the flannel and you find there is electricity on both the flannel and the wax, and that they are of different kinds; we know from past experiments that the electricity on the tube is different from that on the wax; that on the tube we call positive, so that on the wax must be negative; and if that on the wax is negative, then that on the flannel must be positive.

These simple experiments have taught us the fundamental law of electrics, a law that you must thoroughly understand before you can hope to comprehend what is to follow.

Positive electricity repels positive electricity, but attracts negative electricity; negative electricity repels negative electricity, but attracts positive.

But, you may ask, what is electricity? I shall give you what seems to me the best answer to that question. Electricity is certain manifestations of force set free by friction. We do not know what it is, but we know that it is the result of force. I know that rubbing the silk pad upon the glass tube produces friction of the silk upon the glass, which sets positive electricity free upon the glass, and negative on the silk. But should you ask me whence came the force to produce the friction, I must refer you to the air I breathe and the food I eat. Whence comes the food? The vegetables are the result of the union of carbon-dioxide and sunlight, with certain ingredients from the earth; the meat is the result of the vegetable kingdom, which is the result of sunlight.

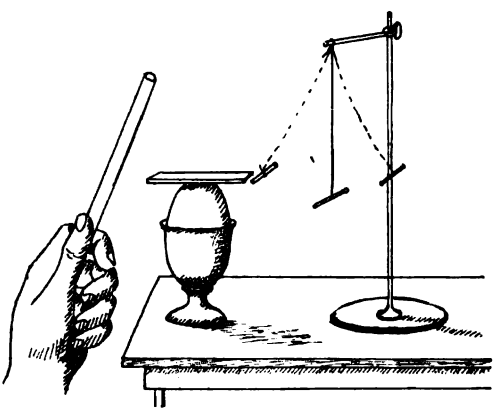

FIG. 29.

Electricity is present in all things at all times, and friction sets it free.

Try a few more experiments. Place the pine stick upon the top of the porcelain egg-cup so it balances, suspend the straw with the silk thread an inch away from the end of the stick but on a level with it. Bringing the tube to the other end of the stick, touch the stick; no result; now rub the tube and bring it near the end of the stick farthest from the straw, but do not touch the stick, and you will observe that the straw flies to the end of the stick, touches it, becomes charged and is repelled. (Fig. 29.) The tube is too far away to attract the straw, yet the straw is attracted to the stick and is repelled. We know there is free electricity upon the tube, but the tube has not touched the stick.

This is something new. We know that there must be electricity upon the stick, for the straw is attracted to it and then

repelled. But how did the electricity get to the stick, the tube has not touched it? It passed through the air to the stick from the tube, and the stick conducted it to the straw. This is what is known as electricity by induction. The electricity in the stick is said to be induced.

Remember this simple experiment, for you will have occasion to use it again.

CHAPTER V.

The Electrophorus—Leyden Jar.

Remembering the experiment of electricity by induction, as shown in Figure 29, let us go farther into the study of electricity by induction.

Take an egg and lay it upon its side in a porcelain egg-cup. Hang the straw held by the silk thread an inch from the small end of the egg; now the tube, after it has been rubbed, is brought near the large end of the egg and instantly the straw flies to the egg, touches it and is repelled. (Fig. 30.)

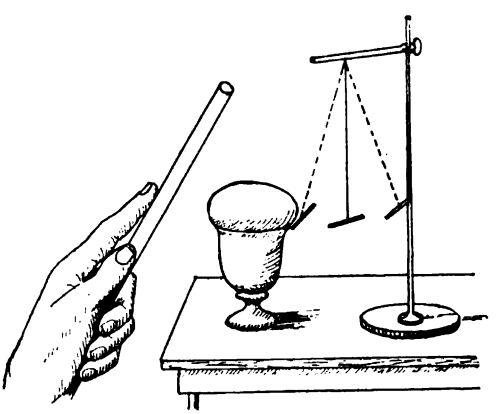

FIG. 30.

Let us see if we can explain this phenomenon. On the tube there is free positive electricity, on the egg there is both positive and negative electricity (as there is in all bodies at all times). When you bring the tube to the large end of the egg, according to the law of attraction the positive electricity on the tube attracts the negative electricity of the egg; so the negative electricity of the egg is gathered at the large end of the egg and held there by the attraction of the electricity on the tube, leaving the positive electricity of the egg free on its small end. The positive electricity at the small end of the egg attracts the straw. You observe when you remove the tube the egg no longer pos-

sesses the power of attraction. The positive electricity of the egg is attracted by the negative electricity of the egg. Bring the egg to the electroscope and you will obtain no result.

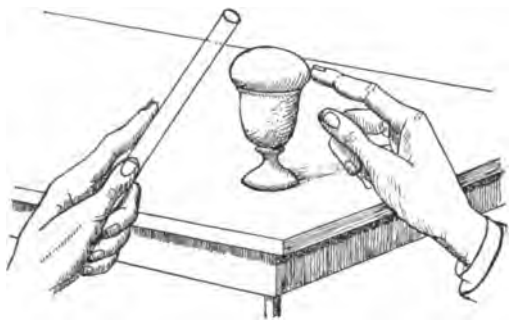

FIG. 31.

Try again. Rub the tube briskly and bring it to the large end of the egg, and while you hold the tube there touch the small end of the egg lightly and quickly with the other hand. (Fig. 31.) Take the tube away, bring the electroscope near the egg and you will see the ends of the leaf stand apart. (Fig. 32.) Bring the straw near the egg and the straw flies to it, remains an instant and is repelled. (Fig. 33.)

Let us try to explain this phenomenon: On the egg there is at all times positive and negative electricity in equal proportions. When you bring the rubbed tube to the large end of the egg the positive electricity of the tube attracts the negative electricity of the egg, leaving the free electricity at the other end; when you touch the other end of the egg with your finger, while you still hold the tube near the large end, the free positive electricity of the egg is discharged through your finger; when you take away the tube negative electricity is left on the egg, and as the egg lies in a porcelain cup, which is a non-conductor, there

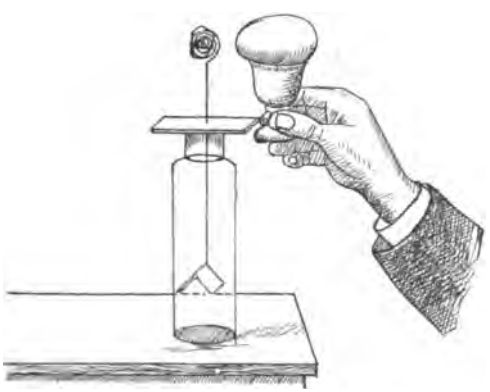

FIG. 32.

remains nothing but negative electricity upon the egg until it has time to take from the atmosphere sufficient positive electricity to equalize it.

Let us see if this correct. Bring your rubbed tube to the straw. The straw is attracted, becomes charged and is repelled. We know it will not come near the tube again until it is discharged. Why? Because it is charged with positive electricity and there is positive electricity on the tube; like repels like. We also know that the straw will now be attracted to negative electricity.

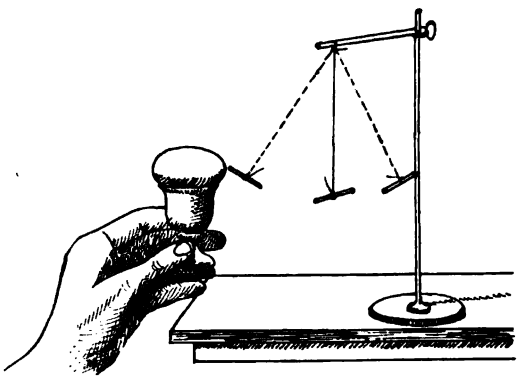

FIG. 33.

Bring the straw near to the egg; instantly it flies to the egg, remains an instant and is then repelled. (Fig. 34.) This proves that the electricity on the egg was negative. This is a simple induction electrical instrument.

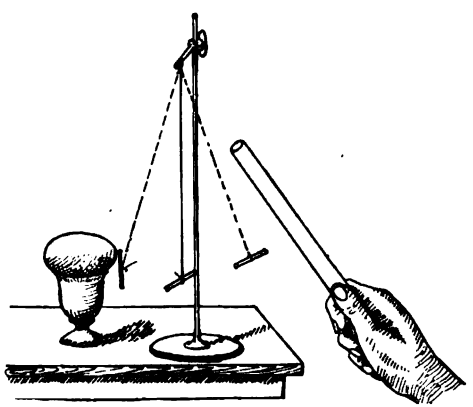

FIG. 34.

Try another, a more complicated experiment, but do not forget the previous one. Taking a piece of hard rubber eight inches square and one-fourth of an inch in thickness having a hole in each corner (Fig. 35), warm it over the gas jet and rub it briskly with a piece of flannel; bring it near the electroscope and the ends of the leaf stand apart. Bring it near the straw and the straw is attracted,

becomes charged and is repelled. Your assistant rubs the glass tube and brings it near the straw; the straw is attracted to the glass tube, remains an instant and is repelled. From previous experiment we know there is free electricity on the hard rubber.

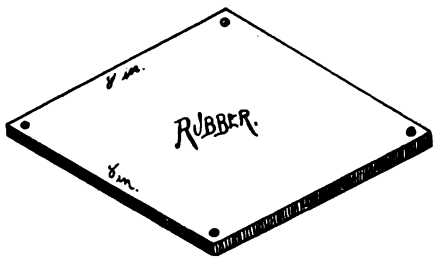

FIG. 35.

Lay the piece of hard rubber on a board and tack it through the holes in the four corners to the board; take a lid of a tin can six inches in diameter which you tack by its center to the end of a short piece of round hard rubber. (Fig. 36.) Rub the square piece of hard rubber briskly for several minutes; lift the tin plate by its hard rubber handle and put it down firmly upon the square piece of rubber; lift it up by the handle and bring it near the electroscope; but no result. Try it again: this time while the tin plate is on the hard rubber touch the top of the plate lightly with the finger of the other hand. (Fig. 37.) Now lift the tin plate by the handle and bring it near the electroscope; the ends of the leaf stand apart. Try it with the paper tassel (Fig. 38), the tufts of cotton and the bits of gold, and you will find it highly electrical.

FIG. 36.

Let us see if we can explain this phenomenon. We know that the rubbing of the square piece of rubber with the flannel sets negative electricity free on the rubber; we know that the tin plate contains positive and negative electricity in equal proportions; when you put the tin plate down on the hard rubber the free

negative electricity on the rubber attracts the positive electricity of the tin and holds it, or, it is said to be bound. While the negative electricity of the plate is free the attraction of the free negative on the rubber is greater than the attraction of the negative on the tin, so the negative of the tin is free to escape by any conductor. Touch the top of the tin plate with your finger; it escapes, and there is left upon the tin plate nothing but positive electricity; lift it up by the hard rubber handle, which is a non-conductor, and test it by bringing it to the straw; the straw flies to it, becomes charged, and flies away. (Fig. 39.) Rub the glass tube, bring it near the straw, and the straw is repelled by it; rub the sealing-wax, bring it near the straw. and the straw is attracted. It was then positive electricity which was on the straw; the straw was charged from the tin plate; so our reasoning is correct. This instrument is called an electrophorus.

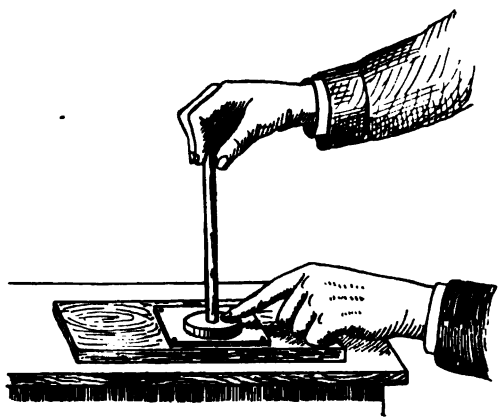

FIG. 37.

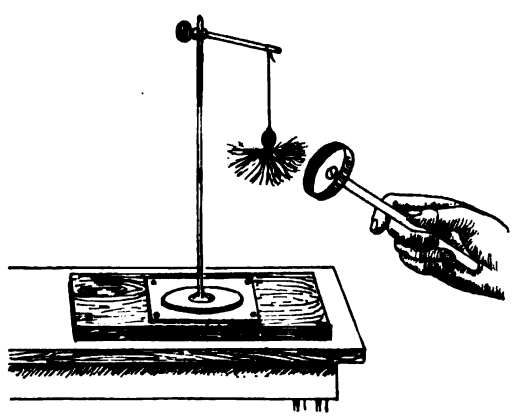

FIG. 38.

Try another experiment with it. Rubbing the rubber briskly with the flannel put the plate upon it; touch the top of the plate with a finger of the other hand; lift the plate by its handle and

bring it to the knuckle of the other hand and you will observe there was a tiny spark attended by a sound and you feel a stinging sensation in the knuckle. (Fig. 40.) We know there was free positive electricity on the plate and there was both positive and negative electricity on your hand. When the plate was brought near your knuckle there was a spark; that spark was the result of some of the negative electricity on your hand being attracted to the plate by the free positive electricity on the plate.

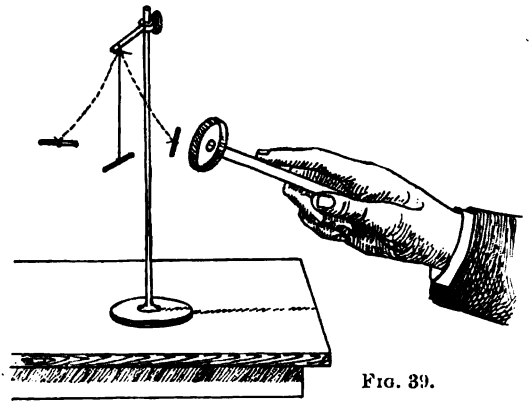

FIG. 39.

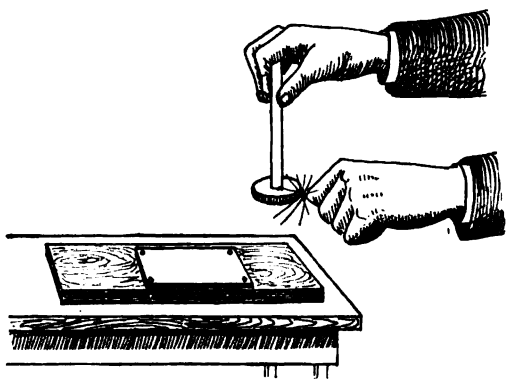

FIG. 40.

Try still another experiment with it. Suspend your paper tassel with a silk thread; put the tin plate on the hard rubber; touch it and bring it to the tassel; instantly each strand of the tassel stands out from its fellow. (Fig. 41.) Repeat it several times until each piece of the tassel is as widely separated from its fellow as possible. Now put your knuckle under-

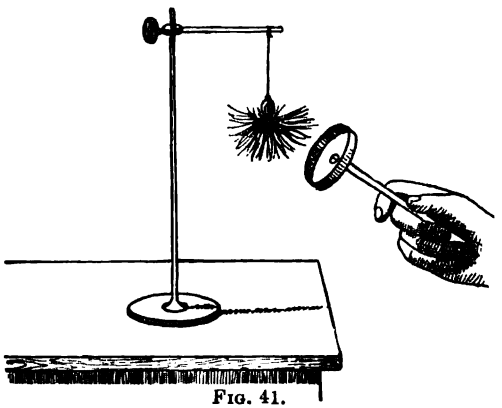

FIG. 41.

neath the tassel, but do not touch it; there is no result. Touch the tassel with your knuckle and slowly the ends of the tassel come together, it requiring several minutes for the tassel to be discharged. (Fig. 42.)

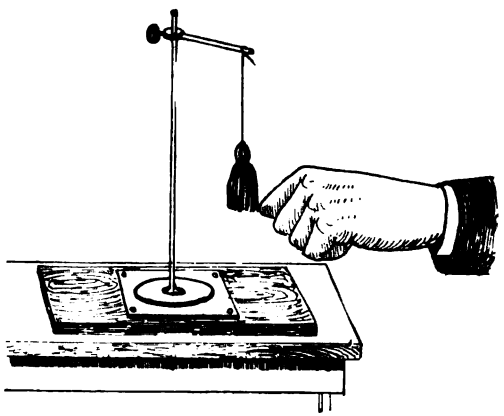

FIG. 42.

With the electrophorus you again charge the tassel until each tiny strip stands as far from its fellow as possible. Take a steel hat-pin six inches long having a steel ball or bead at one end and a point at the other; over this pin slip a small, closely-fitting piece of rubber tubing five inches long, leaving one inch of the point of the hat-pin unprotected by the tubing and the bead also uncovered. Take hold of this pin by its rubber insulation and bring its sharp end near the charged tassel and you will observe how quickly the tassel is emptied of its electricity. (Fig. 43.) Put the tin plate down on the hard rubber; touch the top and lift it by the handle; taking the hat-pin by its insulation bring the bead end near the plate and a spark is the result. (Fig. 44.)

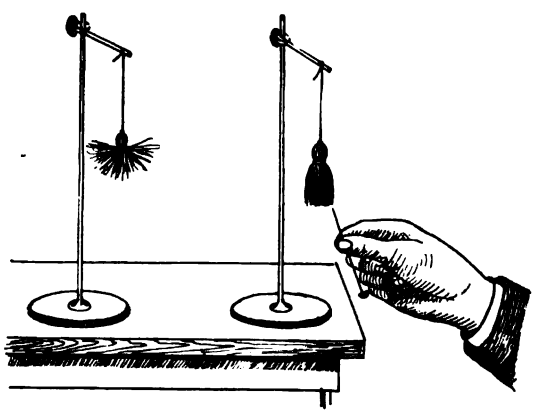

FIG. 43.

Try again. Putting the plate on the hard rubber, touch it and again lift it up; now bring the sharp end of the pin to the

plate; there is no spark but you will hear a hissing sound. The point to which I wish to call your attention in this experiment, as well as in the last, is that sharp points conduct away electricity in silence while blunt ends conduct it away in a spark.

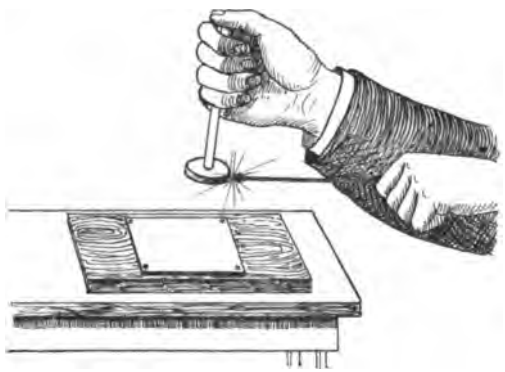

FIG. 44.

I wish to describe to you another instrument. Take a glass bottle which is lined inside and covered outside to within an inch of its top with tin foil; take the wire having one end bent and on the other end the ball of wire from the electroscope and place it in this bottle so that the bent end rests upon the foil in the bottom of the bottle and the piece of wood lies across the mouth of the bottle. (Fig. 45.) Rubbing the hard rubber plate briskly with the flannel, put the tin plate upon it; touch the top and, taking hold of the handle, bring the tin plate to the wire ball and a tiny spark flies from the plate to the wire ball. (Fig. 46.) Repeat this several times; each time a spark will fly to the wire ball. Now take a piece of copper wire twelve inches long covered with cloth and paraffin to within one-half inch of its ends; place one end of the wire against the foil on the outside of the jar and bring the other end near the wire ball. As you will observe there will be a noise and a spark (Fig. 47), the spark being

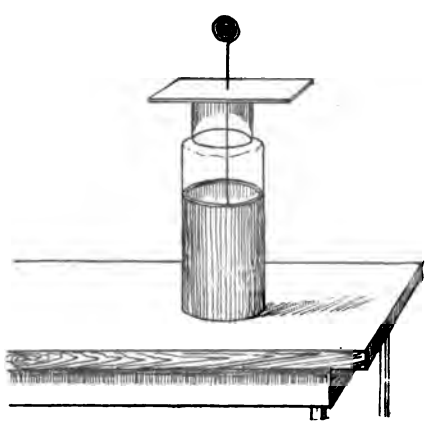

FIG. 45.

many times larger than the spark from the plate of the electrophorus. This is a condenser of electricity and is called a Leyden jar.

We know that the plate, when it is lifted up, contains free positive electricity; that positive electricity passed from the plate to the wire ball, was conducted by the wire from the ball to the bottom of the bottle and collected upon the foil in the bottle; this positive electricity upon the foil in the bottle has attracted the negative electricity of the foil on the outside of the bottle and has held it bound by induction through the glass. This leaves the positive electricity on the foil outside free to escape, which it does through the table upon which it rests. That leaves us negative electricity on the outside of the bottle and positive on the inside; but the glass being a non-conductor, they cannot come together. With the copper wire which is a conductor you connect the foil outside with the foil inside, and a spark is the result. This discharges the Leyden jar, as it equalizes the positive and negative electricity on the inside and outside of the jar.

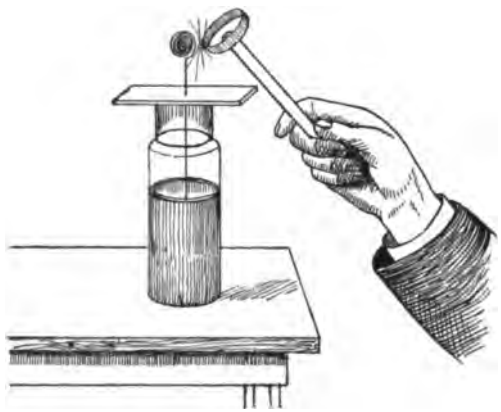

FIG. 46.

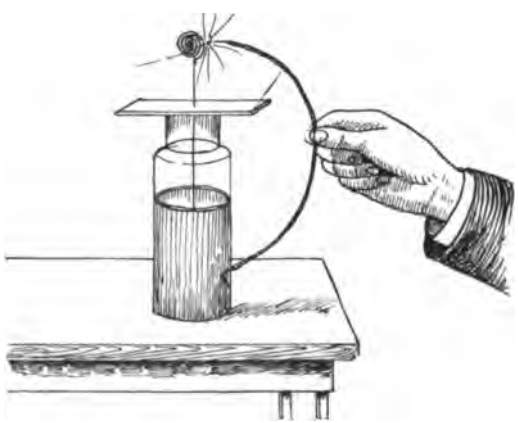

FIG. 47.

CHAPTER VI.

The Static Machine.

So far in your experiments you have been able to obtain only a small amount of free electricity. With the electrophorus and the Leyden jar you were able to obtain quite a spark, but only after considerable labor. A machine has been made that will give you a larger amount of free electricity with less labor. Through the center of a heavy circular piece of plate glass is passed a wooden shaft with a crank at one end; this shaft works into two upright pieces, which allows the plate to revolve; at the lower part of the machine is arranged two heavy pieces of soft rubber, so that the glass wheel runs between and presses closely upon them. (Fig. 48.) These pieces of rubber are connected by copper wire, and the copper wire is connected with the floor; fastened to a round piece of hard rubber is a brass rod on a level with the shaft through the wheel; on the end of this brass rod is a metal comb. The teeth of the metal comb come very near but do not touch the glass wheel; the brass rod is connected by means of a copper wire with the wire which goes to the bottom of a Leyden jar; if you turn the crank which causes the glass wheel to revolve you know that the friction of the rubber upon the glass wheel will set electricity free; that there will be free positive electricity upon

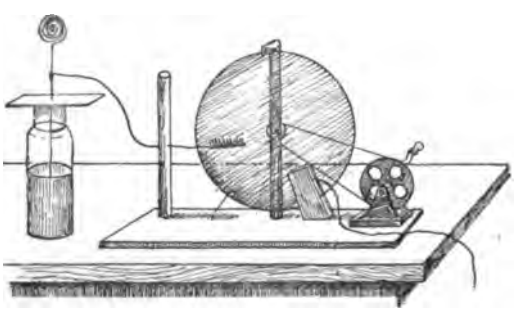

FIG. 48.

the glass wheel after it passes through the rubber; and that there will be free negative electricity upon the rubber. The free negative electricity of the rubber will be conducted to the floor by means of the copper wire. As the glass wheel is turned, that part of it which has passed between the rubbers comes nearer and nearer to the metal comb. The points of the comb gather this positive electricity, conduct it to the brass rod and from the brass rod it passes over the copper wire to the Leyden jar. Now, if our theory is right and the construction of our machine is correct, we know that we will produce a spark by touching with a wire the outside foil of the Leyden jar and the ball of wire connected with the wire within the jar. Taking a piece of insulated wire with its ends bare, touch the outer foil with one end of the wire and the wire ball with the other end, and you will observe a large spark. To obtain good results with the machine the air should be as dry as possible, as moist air is a fairly good conductor.

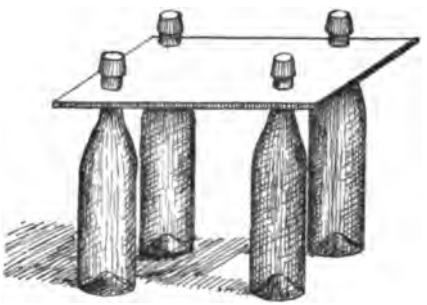

FIG. 49.

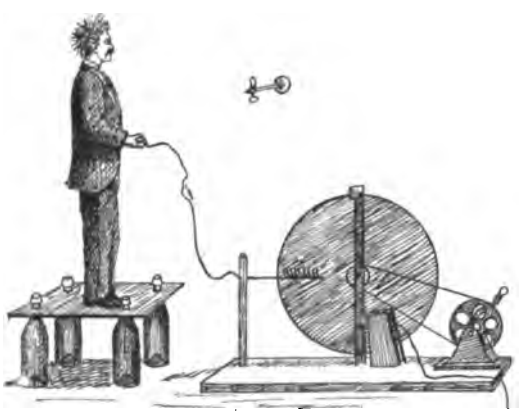

FIG. 50.

Try another experiment. Take a piece of two-inch plank eighteen inches wide and two feet long; in each corner make a hole an inch in diameter; through each hole thrust the neck of an empty beer bottle; you observe it makes an insulated stool (Fig. 49);

your assistant stands upon it and taking hold of the copper wire that was attached to the Leyden jar, holds it lightly, while you turn the glass wheel by means of the crank. Watch his hair, see how it stands on end, each hair separate from its fellow (Fig. 50); touch your finger to his and a spark is the result. What has happened? By holding the wire which is connected to the brass comb he has become charged with free positive electricity; his hair stands apart because each hair is charged with free positive electricity, and like repels like; when you touch his hand his hair assumes a natural condition, because he is discharged, as a Leyden jar is discharged. A spark flies from your finger to his, because the negative electricity of your body is endeavoring to neutralize the excess of positive electricity in his, and a spark is the result; but remember that he stands upon an insulated stool, a stool which has non-conductors for its legs.

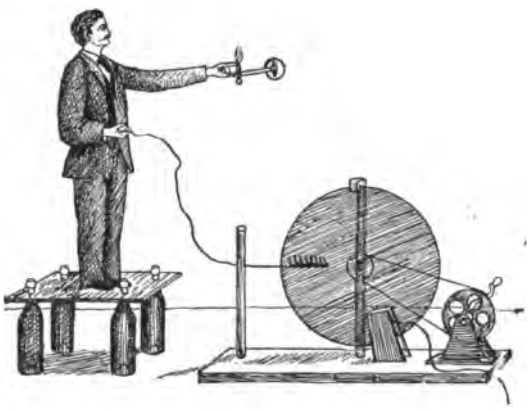

FIG. 51.

Try one more experiment. While he holds the wire connected with the machine, turn the crank until you think he is thoroughly charged; turning on the gas, have him touch the tip of the jet with his finger and the gas will be lighted. (Fig. 51.)

This is easily explained: the negative electricity of the earth with which the gas pipe is connected has leaped from the gas jet to his finger, and a spark which lights the gas is the result. So you might perform many experiments with this home-made machine, which is called a Static machine.

Figure No. 52 is an improved McIntosh Static Machine. You will observe there are two glass wheels, one larger than the other; the large one is stationary, the small one revolves

by means of a belt over a pulley; on either side of the revolving plate you will see some brass brushes; on either side, on a level with the center of the wheel, you will see a metal comb. Each metal comb is connected by means of a brass rod to a Leyden jar; on the board between the two Leyden jars you observe a switch, which may be opened or closed; the points of this switch are connected with the outside of the Leyden jars.

I am not going to attempt to explain to you how the wire brushes set positive electricity free upon one side of the revolving

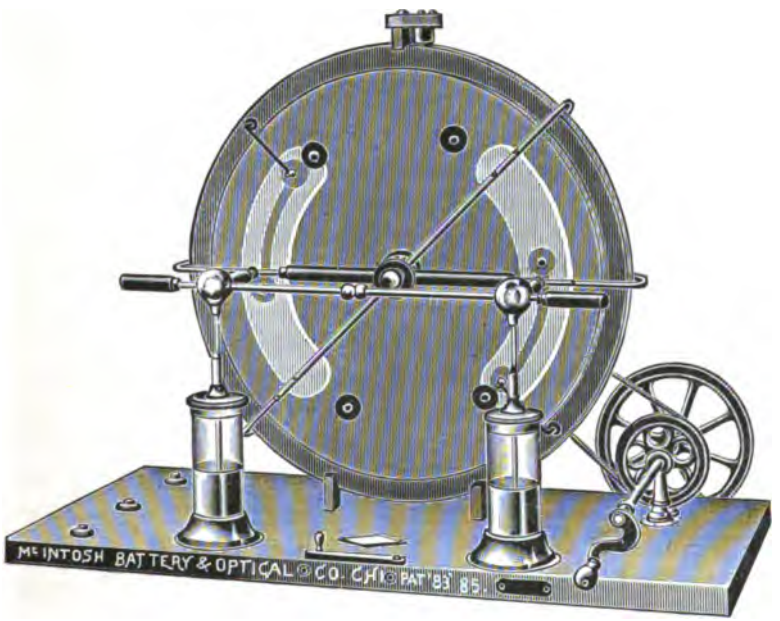

FIG. 52.

wheel, and negative electricity on the other side; it is enough for you to know, and all you need remember, that on the inside of one of these Leyden jars there will be gathered positive electricity, and on its outside negative electricity; while on the inside of the other Leyden jar will be gathered negative electricity, and on its outside positive electricity. If this is true, after you have turned the wheel, by bringing the brass rods on the top of the Leyden jars together you should obtain a spark, which you will; by having

the switch open and connecting the outsides of the jars by a wire you should obtain a spark, which you do.

So far, in considering this subject, you have learned:

1st. That electricity is a manifestation of force.

2d. That it is set free by friction.

3d. That it possesses the power of attraction and repulsion, and that unlike attracts and like repels.

4th. That it has polarity, as exemplified by the straw charged by the glass tube, and is attracted by the sealing-wax.

5th. That electricity acts by induction.

6th. That there are conductors and non-conductors.

7th. That blunt ends conduct away electricity with a spark, and sharp ends conduct it away in silence.

8th. That electricity may be bound or held, as was the negative on the large end of the egg, and the positive on the under surface of the tin plate of the electrophorus.

This form of electricity is called static, frictional, atmospherical, or Franklinic electricity; static being the most common term.

The grandest manifestation of static electricity is the lightning. From the friction of the earth upon the clouds and the clouds upon the earth, there is free electricity in the air at all times. A cloud becomes charged with positive electricity; the positive of the cloud attracts the negative of the earth, the negative of the earth goes up a tree or a house to meet the positive of the cloud, and a flash and a report is the result.

By the friction of cloud upon cloud, one cloud becomes charged with positive electricity, and another with negative electricity; they come near enough for induction to take place, and a flash is the result; this is the so-called sheet-lightning.

It was Benjamin Franklin who first established the identity of lightning with static electricity; putting up, during a thunder storm, a silk kite with a steel point at its top, the steel point gathered the free electricity from the air, and the wet kite string, being a conductor, conducted the electricity to Franklin. At the end of the kite string he had a brass key; the brass key was attached to a dry silk ribbon; holding the silk ribbon (which you

will remember is a non-conductor when dry) in one hand, he touched a knuckle of the other hand to the brass key, and a spark was the result. From this experiment came the lightning-rod, which is used all over the world.

You have spent some time in the consideration of this kind of electricity, not because it is used very extensively as a therapeutic agent, but in order that we might inculcate in your mind a few of the laws and principles of electricity. Study this repeatedly, performing the experiments as often as possible. If you thoroughly understand what you have already studied more than half your work is done.

CHAPTER VII.

Magnetic Electricity.

This branch of electricity presents many points that are difficult to comprehend or explain fully without taking more space than is profitable in a work of this kind; fortunately a full comprehension of it is not essential for the therapeutist. I will, therefore, in part, give you arbitrary statements, and, so far as is necessary, the experiments and explanations.

It was found that two pieces of iron ore, apparently just alike in all respects, one of them from Magnesia, the other from a non-magnetic mine, would cause very different results when brought near iron filings, tacks, etc.

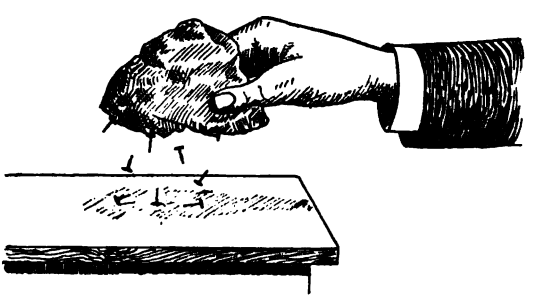

FIG. 53.

Have some iron filings and tacks on a table; bring the non-magnetic ore near them and nothing occurs; touch them, still no result; rub your ore on the silk pad and try it and no result follows; rub it with the flannel and still no results follow; bringing it near to or in contact with the filings or tacks it has no power of attraction, and the methods you have found to develop this power on glass or sealing-wax will not develop it in the iron ore. Take the piece of ore from Magnesia, bring it near the table and you will see the iron filings and the small tacks performing the same

phenomena that the bits of gold and the tufts of cotton did with the glass tube after it had been rubbed. (Fig. 53.) This iron ore is called a natural magnet or loadstone because it was first found near Magnesia. The attraction which the loadstone has for the bits of metal is known as magnetic attraction.

Not many years ago it was discovered that if a piece of hard steel was rubbed in one direction with a natural magnet for a short time the steel became a magnet. Take your penknife and rub it in one direction ten or fifteen times on the loadstone and you will find it possesses the power of attraction for the filings and the tacks. (Fig. 54.) Figure 55 represents a piece of hard steel polished and bent in the shape of a horse-shoe. When you bring it to the tacks and the iron filings they are strongly attracted to it; but notice that this horse-shoe magnet, as it is called, possesses the power of attraction stronger at its ends and that the attracting power grows less as you go back on the steel towards the bend, and, as you will observe, it is lost within a short distance of the ends of the magnet. One end of this magnet is positive and the other end negative; this is what is known as a permanent magnet. The little piece of steel which fits over the ends of the magnet is known as an armature; its object being to prevent the magnet from losing its power of attraction. When the magnet is not in

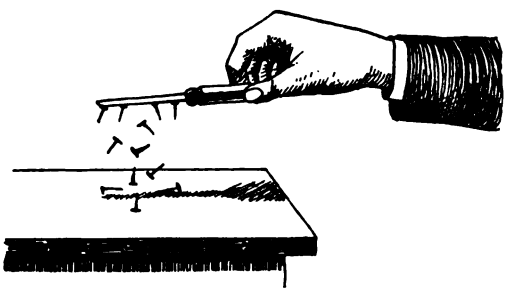

FIG. 54.

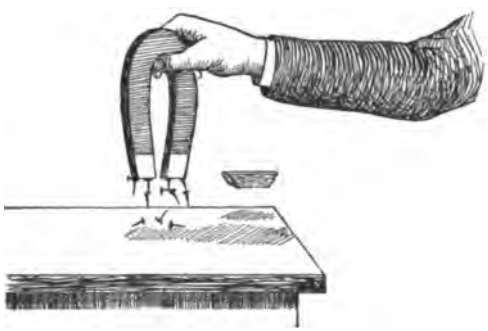

FIG. 55.

use the armature should be in place. Try with the tacks again: One tack will be attracted to the end of the magnet, another tack to the first tack, a third to the second, and so on until you have ten or twelve tacks hanging together. (Fig. 56.) The first tack is attracted to the magnet and becomes, while it is in contact with the permanent magnet, a temporary magnet. And so in turn do all the other tacks. These tacks are temporary magnets and are made so by what is called magnetic induction.

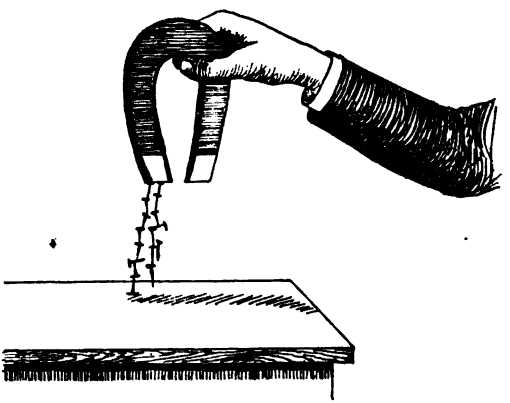

FIG. 56.

Take a knitting needle and rubbing it a number of times in one direction over the magnet you will see that it is highly magnetic, but only at its ends. (Fig. 57.) This will make it a permanent magnet.

So far we have studied three kinds of magnets, viz.:

1st. The natural magnet, or loadstone.

2d. The temporary magnets, which are of soft iron, made magnets by magnetic induction as shown by the tacks.

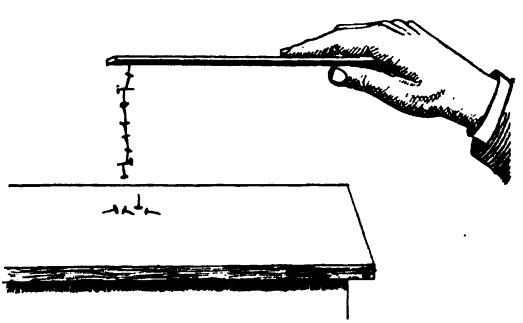

FIG. 57.

3d. The permanent magnets made of hard steel by being rubbed on a natural magnet or upon another permanent magnet.

Most permanent magnets are now made by placing the hard steel on a dynamo or electric power machine. There is one other

kind of magnet which we will take up later on, making four kinds of magnets.

Let us try a few experiments in magnetic attraction. Suspend from its center by a silk thread the knitting needle which you made into a permanent magnet by rubbing it on the horse-shoe magnet; it wavers a few minutes but finally stops, pointing north and south. Now take the horse-shoe magnet and covering the end marked "P" or "positive" with the hand, thus insulating it, bring the other end which is marked "N" or "negative" near the suspended needle (Fig. 58) and you will observe that one end of the needle will be attracted to it. Take the magnet away from the knitting needle and allow the needle to stop; now bring it to the other end and you will see that the end of the needle is repelled and no amount of persuasion will bring it near the magnet. (Fig. 59.)

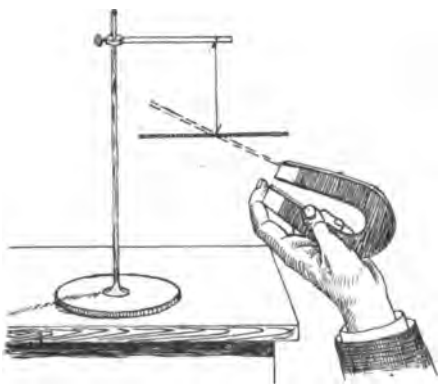

FIG. 58.

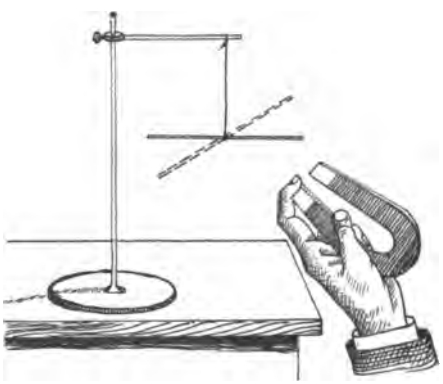

FIG. 59.

What does this mean? Our law of attraction says unlike attracts and like repels. The end of the magnet is negative. The first end of the needle which you tried was attracted, therefore it must be positive; the second end of the needle was repelled, so it must be negative; therefore our law of attraction holds good with magnets.

Figure 60 is what is called a compass. The needle points north and south; bring one end of the knitting needle to the north end of the needle of the compass and the end of the needle of the compass is repelled. (Fig. 60.) The end of the knitting needle that was brought to the north end of the compass needle we found to be the negative end of the knitting needle, therefore the north end of the needle of the compass must be negative. Try the negative end of the knitting needle to the south end of the needle of the compass and you will find that the south end of the needle of the compass is attracted; therefore the south end of the needle of the compass is positive. (Fig. 61.)

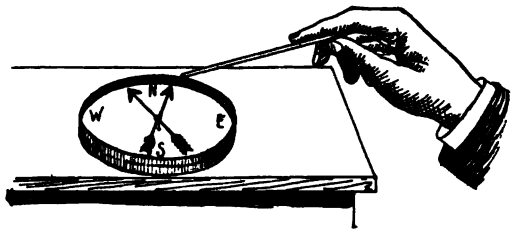

Fig. 60.

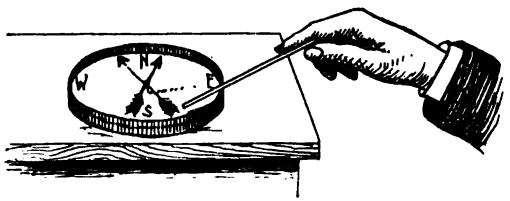

Fig. 61.

But why does the needle of the compass always point north and south? The north pole of the earth is said to possess positive magnetic attraction, and the south pole of the earth negative magnetic attraction. One end of the needle of the compass is positive and the other is negative. The negative end of the needle is attracted by the positive

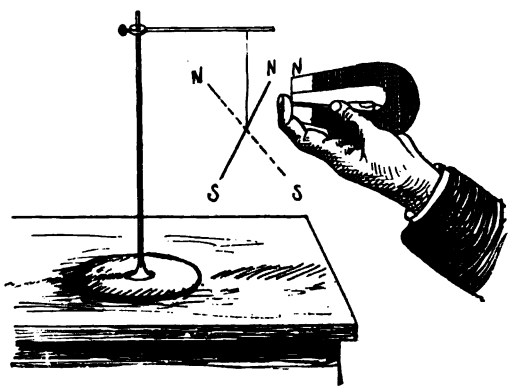

Fig. 62.

(Fig. 62) attraction of the north pole, according to our law of attraction.

Remember these facts about magnets and magnetic induction, for we will have occasion to use them later on in our study.

CHAPTER VIII.

The Galvanic Current.

Up to this time the free electricity which we have obtained has manifested itself only in sparks and lasted but an instant. We wish to obtain electricity in a more constant condition, or in other words, we want what is called a current of electricity. It is difficult to explain what we mean by a current of electricity. I have told you that there is positive and negative electricity in all things at all times; now how can we obtain a current? By disturbing the equilibrium of electricity on the conductor. The easiest way to illustrate this is by an experiment which all of my readers, no doubt, have tried many times.

FIG. 63.

Take a dozen brick, each one eight inches long, and stand them in a row on their ends six inches apart. (Fig. 63.) Touch the first brick with the hand, and it falls over, knocking down the second brick, which in its turn knocks down the third, and so on until they are all down. (Fig. 64.) You touched only the first brick, but by disturbing its equilibrium you disturbed

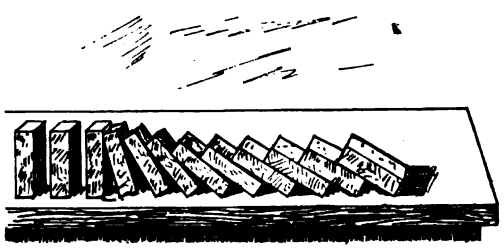

FIG. 64.

the equilibrium of them all. Such probably is the case with what we call a current of electricity.

You found by some of the earlier experiments that, as you set positive electricity free on any object, it would repel or drive before it the positive electricity already there; by continuing to supply new positive, you continue to force along the conductor charge after charge; thus creating a constant flow of this subtle force or fluid along a conducting medium. So far, however, you have been unable to make practical use of this fluid except by discharging it in the form of sparks which permits of no permanent or continuous action.

Galvanism is that form of electricity which is set free by chemical action.

The first experiments with galvanic electricity were made by taking a piece of blotting paper and wetting it in an acid solution, then putting upon this blotting paper a piece of sheet copper, upon the copper a thin piece of blotting paper treated as the first; upon the second piece of blotting paper a piece of zinc, upon this another piece of similar blotting paper; upon this, another piece of sheet copper, upon that another piece of blotting paper, and on it a piece of zinc, and so on until quite a pile was made; this is a voltaic pile. (Fig. 65.)

Try a simple experiment: Take a copper cent twisted on the end of a copper wire, a silver quarter twisted on the end of another copper wire, and put the free end of one of these wires under the tongue, and the other above it; there is no result. Now, put the cent and quarter in a glass of water to which a small quantity of sulphuric acid has been added, being careful not to allow them to touch each other. Putting the end of the wire from the cent under the tongue, and end of the wire from the quarter above the tongue, you will experience a peculiar metallic

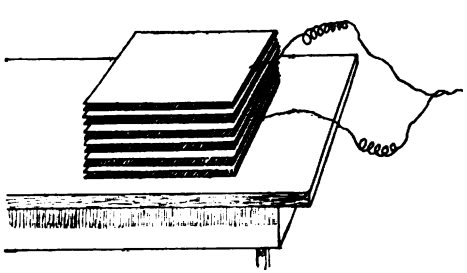

FIG. 65.

taste; this taste was not present when the cent and the quarter were out of the glass. This is called a galvanic cell and the taste is due to galvanic electricity. The word cell in this case means a receptacle in which chemical action takes place. (Fig. 66.)

A galvanic cell consists of two unlike materials, generally metals which are partly or wholly immersed in an acid solution, and so placed that they do not come in contact with each other; no chemical action occurs until these metals are connected, either within or without the cell. There are certain things which are necessary in order to have a perfect galvanic cell or battery.

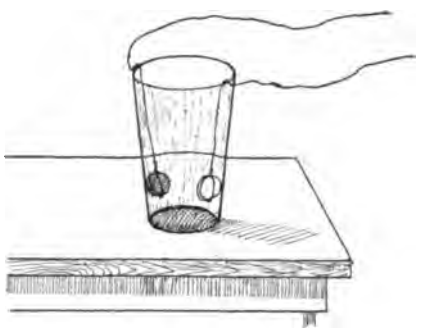

FIG. 66.

1st. A generating plate which is acted upon to a greater extent by the acid solution.

2d. A collecting plate upon which the chemical action has little effect.

These are known as the elements of the battery or cell; these elements must be destroyed by the chemical action at different rates of destruction. We will try to make this plainer a little later. When these elements are connected the battery will work until the elements are destroyed, or the solution exhausted.

We now come to a word which is used very extensively in electrics, and one which must be understood, viz.: circuit. By the circuit we mean the fluid in the battery, the elements which are the two plates, or the generating and the collecting plates, and the wire or other conducting medium used to connect the two plates. To illustrate, let us begin with the collecting plate; a wire is connected to the collecting plate, and taking one end of that wire in your left hand, with the right hand hold the end of the wire which is connected with the generating plate; the circuit is then formed by the collecting plate, the wire from the collecting plate, to the

left hand, your arms and body; the wire from the right hand to the generating plate, and from the generating plate by the fluid to the collecting plate. If you let go the wire in the right hand, it is said to be an open circuit; when you take hold of the wire again, the circuit is said to be closed; if the generating and collecting plates should be connected within the cell, or upon the top of the cell, it would form what is called a short circuit; if anything should break or cut the wire between one of the plates and the hand, it would be called a broken circuit; in other words you must have a continuous, unbroken conducting medium from the collecting plate, outside the cell back to the generating plate, and within the cell, from the generating plate to the collecting plate. (Fig. 67.)

The direction of a galvanic current is always in one way; it begins at the generating plate, which is positive. At this generating plate, molecules (if we may be allowed the term) of positive electricity are set free. Now you will remember that like repels like; the molecules of electricity set free at this generating plate remain there until another set of positive molecules is set free. As the first set is positive, it is repelled by the second set, and must move on; and in like manner the second set is repelled when the third set is freed, and so on.

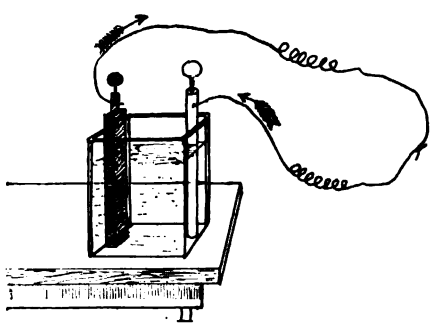

FIG. 67.

These molecules of electricity are gathered upon the collecting plate, some of them are attracted by the negative elements of the collecting plate, but the negative molecules are so few in number, and the positive molecules are being urged on in such quantities by the new comers behind that they find their way over the collecting plate to the wire, and are conducted by the wire through the circuit and back to the generating plate. Remember this, that the size of the elements in the cell have nothing to do with

the direction of the current; the current will pass precisely in the same direction from a cell the size of a thimble as it will from one as large as a barrel. The direction of the current is always from where there is the most chemical action. (Fig. 68.)

This brings us to the consideration of a word that hereafter we will use a great deal and we must understand it; it is the word poles. I can conceive of one reason only why the term poles is applied, and that is because the north and south poles of the earth were opposites and possessed the power of attraction.

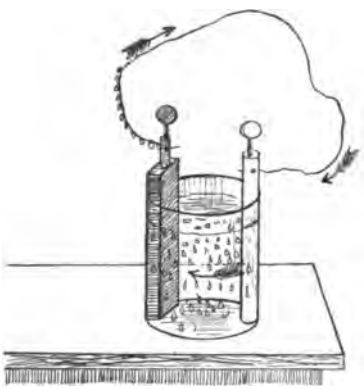

FIG. 68.

Now retain these points in your mind; each cell contains two elements; these elements are usually of different kinds of metal; one is destroyed by chemical action at a far greater rate than the other; this element throws off molecules of positive electricity and is the positive element. But observe: these positive elements, or molecules, as fast as they are thrown off, are repelled from the positive plate; they collect upon the collecting plate which is the negative plate, and pass out over the collecting plate and the wire connected with it; so although this wire comes from the collecting plate it is conducting positive electricity. We call this wire connected with the collecting plate the positive pole of the battery, and that connected with the generating plate the negative pole. You see the positive element in the cell is the negative pole outside the cell, and the negative element in the cell is the positive pole outside the cell.

The material now most generally used for the generating plate is zinc, although other materials have been used. For the collecting plate carbon is the one most often used, next copper and then platinum. Pure zinc is not used, but what is known as commercial zinc; this commercial zinc contains some impurities, such as iron and arsenic. These impurities in the zinc form a circuit

between themselves and make what is known as local action; this local action, although very slight, will eventually exhaust the fluid. When you wish to prevent local action, immerse your generating plate in an acid solution and brush over it bi-sulphide of mercury; this is called amalgamation, and is never used on a platinum plate.

Now we come to a word that always puzzles the student; it also puzzles the practitioner and the electrician, yet we must know something about it, and that word is potential, or, as it had better be called, electric level. Note a few facts before we proceed any farther; the potential of elements is made by chemical action in the cell, the current is produced by trying to equalize the potential. Perhaps you can understand this better by an illustration. Figure 69 shows two barrels connected by a pipe an inch in diameter with a valve in the pipe between the barrels. One barrel is filled with water, the other is empty. Now you know that if the valve is opened the water will flow through the pipe into the empty barrel; at first it will flow very rapidly, but as the water accumulates in what was the empty barrel, the flow becomes slower and slower until it finally ceases. This is the much vexed and little understood potential.

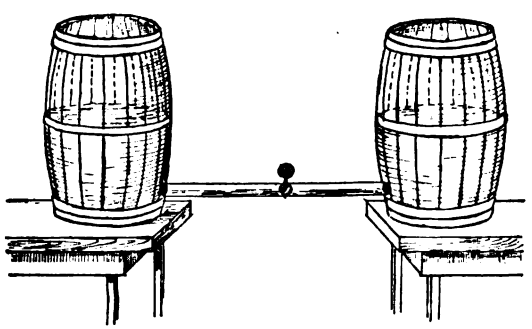

FIG. 69.

The elements of a battery must be of different potential; when the barrels are each half full of water no flow takes place; one must contain more than the other. In the galvanic cell when the potential of the elements are equal the current ceases, just as the water ceases to flow through the pipe when it has reached the same height in both barrels.

Now certain things will modify a current of electricity.

1st. The length of the circuit; you know that if the pipe

between the barrels is two feet long the water will flow into the empty barrel much quicker than if the pipe was twenty feet long.

2d. The diameter of the conductor; you are well aware if the pipe connecting the barrels is four inches in diameter in place of one inch, that the water will pass much more rapidly.

3d. The freedom from obstruction to the passage of the current; you understand if the valve is only partly turned the water will not pass as freely as if it was entirely open.

4th. The difference of potential at the beginning; you know the water will flow much more rapidly, for a time at least, into the empty barrel if the other barrel is entirely full of water, than if it is only two-thirds full.

We have only touched upon these subjects, giving you enough to comprehend what is meant by the terms, and at the same time giving you all it is necessary to know in order to use electricity as a therapeutic agent.

CHAPTER IX.

Electro-Magnets.

In this chapter we will try some experiments in galvanic electricity.

Take a piece of zinc and a piece of carbon, which, as you know, constitute the elements of a battery; put them in a glass jar two-thirds full of water and add some sulphuric acid; connect them with a piece of insulated wire; that is, a wire covered with cloth and paraffin. Twist the free end of the wire which is attached to the zinc around the end of a file, take the end of the other wire and scrape it along the file and you will observe a string of small sparks. (Fig. 70.) This is electricity by chemical action or, properly speaking, electricity by friction, for chemical action is friction. Untwisting the wires from the end of the file, twist their ends together and hold them over the needle of the compass and you will observe a curious action of the compass needle; instead of pointing north and south it will point east and west. This is something new, and it is also something which electricians have studied for years, but we will not attempt any explanation now.

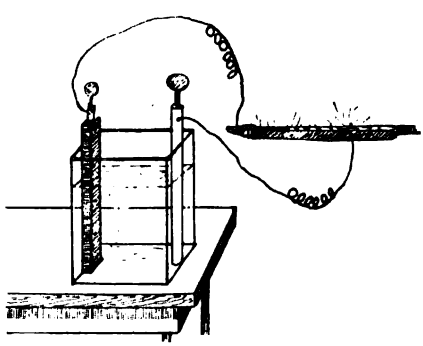

FIG. 70.

Try another experiment. Take the knitting needle which you made into a permanent magnet by rubbing it on the horseshoe magnet and suspend it by its center with a silk thread; it

wavers but finally stops, pointing north and south. From past experiments you know that the end of the knitting needle pointing to the north is negative, and the end pointing to the south is positive; now taking the end of the wire which is connected with the carbon bring it to the north end, west of the needle, and the wire from the zinc of the cell bring to the south end of the needle and you will observe the needle is attracted to the wire from the carbon. (Fig. 71.) Take both wires around to the other side of the needle so the wire from the carbon is at the north end of the needle, but is east of the needle, not west, and you will observe that the north end of the needle is attracted to the wire. Reverse the wires, placing the wire from the carbon near the south end of the needle, and you will observe that the south end of the needle is repelled, not attracted.

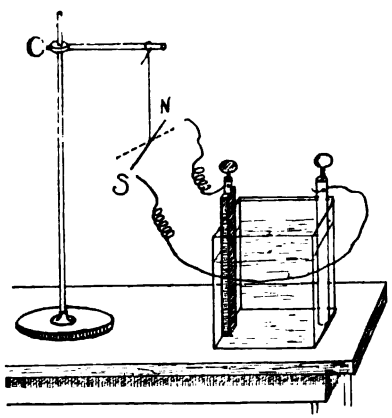

FIG. 71.

Let us try to explain this phenomenon. The north end of the needle we know to be negative; we also know that the zinc sets positive electricity free; that the first set of molecules of positive electricity is repelled by the second set, and the second set is repelled by the third set, and so on. These molecules of electricity collect upon the carbon plate and are conducted from the carbon plate by the copper wire; this copper wire is then conducting positive electricity; the end of the wire is positive and the north end of the needle is negative. According to our law of attraction, the needle being free to move, its north end should be attracted to the wire, and such you find to be the case. The south end of the needle should be repelled from the wire of the carbon, as the south end of the needle is positive and the wire is positive, and like repels like.

This is your first practical experiment. Let me tell you why. You wish to know which is the positive and which is the negative

pole of your battery. Bringing the wires near the needle of your compass, the one at the north end of the needle attracts the needle, therefore it is the positive pole; if it should repel the needle, it is the negative pole.

The next experiment with our galvanic cell is one I wish you to observe very closely, as upon it hinges the comprehension of many things.

Take a piece of soft iron ten inches long and three-eighths of an inch in diameter; hold this piece of soft iron over the iron filings and the tacks and no result follows; put it on the tacks and filings and still there is no result. Now observe closely the steps of the experiment. Take a piece of fine copper wire which is covered with silk (which you will remember is a non-conductor), or in other words, a piece of wire insulated with silk, and wrap several yards of the silk-insulated wire around this bar of soft iron. (Fig. 72.)

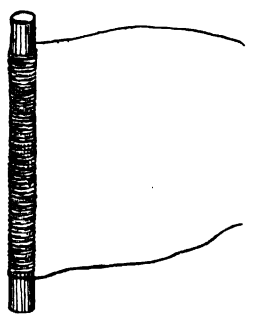

FIG. 72.

Try both ends of the bar on the filings and tacks, but there is no result; taking one end of the wire, connect it to the wire from the zinc in the cell; the other end of the wire connect with the end of the wire coming from the carbon of the cell; trying the ends of the bar to the tacks and the iron filings, they are immediately attracted to it (Fig. 73) and it becomes a magnet. Untwisting the end of the wire wrapped around the bar from the end of the wire coming from the zinc, bend them into the shape of a loop, and bring them together as you would the hook ends of two button hooks; holding them tightly together, one in either hand, while your assistant

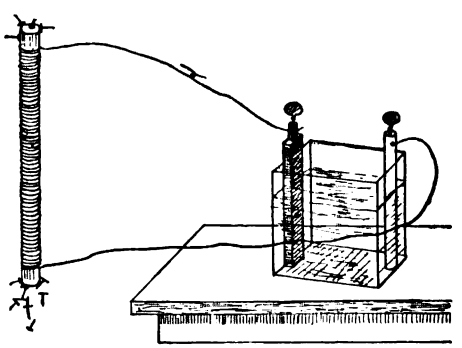

FIG. 73.

brings the bar of soft iron near the iron filings and tacks, they are again attracted, and he holds it up with the tacks and filings adhering to the ends of the bar. Separate the wire hooks and instantly the tacks and filings drop from the bar. (Fig. 74.)

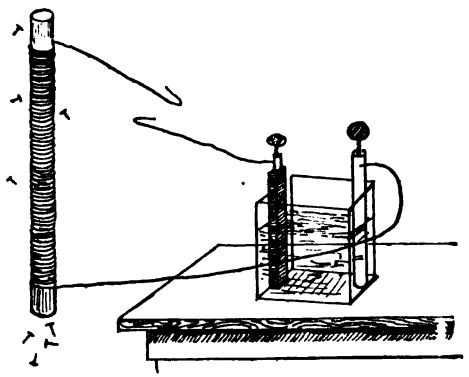

FIG. 74.

Your assistant brings the bar to the tacks again but they are not attracted until the hooks are brought together. You try this bar of soft iron and find it possesses no power of attraction; you wrap it with an insulated copper wire and try it again; still there is no power of attraction; but when you connect it with your galvanic cell and close the circuit (which you do by twisting the ends of the wire together) the bar of soft iron becomes magnetic; but just as soon as you break the circuit by untwisting or unhooking the wires the bar loses its power of attraction.

We have already studied natural magnets or loadstones which possessed this power of attraction; permanent magnets made of hard steel; and temporary magnets, which were magnets only when in contact with permanent magnets; but this bar of soft iron is a magnet only when it is wrapped with insulated wire and the wire is connected with a galvanic cell. It is called an electro-magnet.

The discovery of the electro-magnet is the greatest yet made in electricity. It is the most important instrument in the world to-day, and its discovery is next in greatness to the art of printing. This little instrument—a bar of soft iron wrapped with an insulated wire connected to cells—allows you to speak to your friend a thousand miles away. Upon this instrument depends the electric bell, the telephone, the telegraph and the electric motor. It is a wonderful instrument, yet an exceedingly simple one: an

electro-magnet, a bar of soft iron wrapped with an insulated wire connected to a galvanic cell, possessing magnetic attraction when the circuit is closed and losing it when the circuit is opened.

Figure 75 shows two bars of soft iron, each passing through the center of a spool; they are connected at their ends by a piece of soft iron half an inch wide and two inches long; the spools are wrapped with fine insulated copper wire, a continuous wire; one spool is wrapped, then the wire carried across and the other spool wrapped in like manner, leaving an end of wire coming from each spool. When you try these bars of iron to the tacks there is no result. Connecting the bars of iron with the zinc and copper of the battery the bars of iron become at once magnetic. (Fig. 75.) Untwist one wire and bend the end of the wire from the battery into a hook, and the end of the wire from the spool into a hook also, so that you can make or break the circuit, and you observe that when the circuit is made the pieces

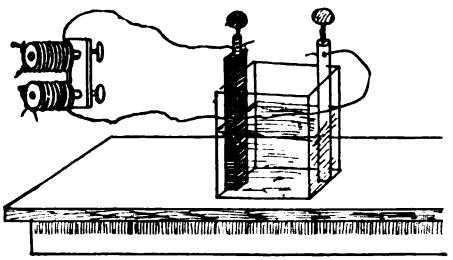

FIG. 75.

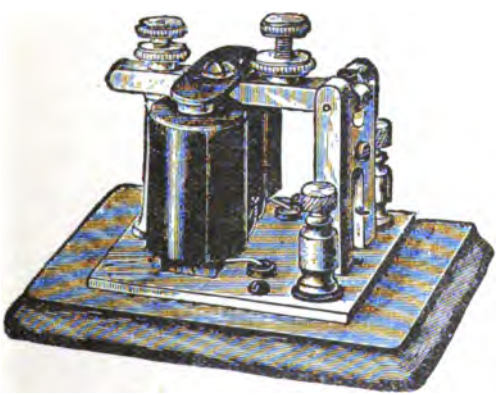

FIG. 75A.

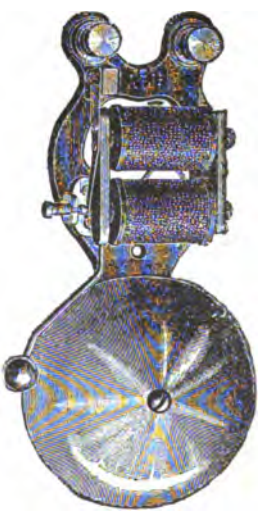

FIG. 76.

of iron possess the power of attraction, but lose it instantly if the circuit is broken.

Figure 75A shows two spools set into a plate so that a piece of soft metal may come in contact with the ends of the pieces of iron which pass through the center of the spools; this piece of metal is attached to a metal bar which works on a pivot; to the other end of the bar is attached a spring which can be regulated by a thumb-screw. Close the circuit and the bars of soft iron become magnets, the piece of metal on the bar being drawn down to them break the circuit and instantly the pieces of soft iron lose their power of attraction, and the spring at the other end of the bar lifts up the metal plate from the ends of the spools. You no doubt recognize in this the Morse telegraph instrument, the discovery of which has annihilated space.

Figure 76 shows the same spools fitted into a bar where, as you observe, there is a piece of flat metal having a clapper on its end, and so set that it may come in contact with the ends of the spools. Closing the circuit the spools attract the metal and the clapper strikes a bell, and we have the electric bell.

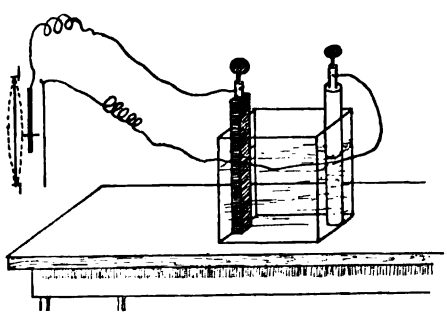

FIG. 77.

A later discovery and one which bids fair to rival the telegraph is that of the telephone. A few words in regard to it here will not be improper. The telephone consists of a transmitter, which is simply a piece of tin-plate with the fine point of a pin which passes through a spring resting against its back; the waves of sound from the voice vibrate the tin-plate, the pin vibrates on the end of the spring, and the point of the pin farthest from the plate strikes a metal bar that completes the circuit. (Fig. 77.)

The other part of a telephone is a receiver, which consists of a bar of iron passing through the center of a spool, the spool being wrapped with insulated wire; set so as to come in contact

with this bar of iron is a tin plate; when the circuit is made through the spool the iron becomes magnetic and the plate is attracted to it; when the bar loses its power of attraction the electricity of the plate causes it to rebound. By this means the same vibrations transmitted by the voice to the tin plate of the transmitter are reproduced in the tin plate of the receiver (Fig. 78), simply because a piece of iron may become an electro-magnet.

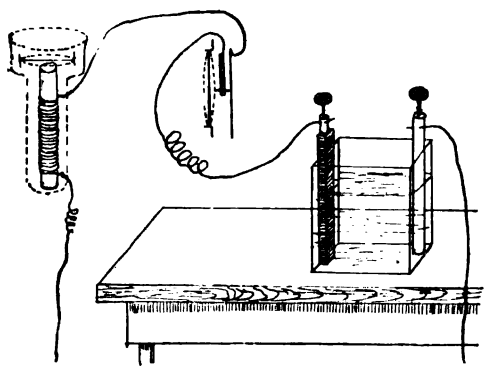

FIG. 78.

In all these experiments with the electro-magnet you have used two wires, one coming from the carbon and the other from the zinc of the battery; but with the telephone and the telegraph instruments they use one wire only.

Let us try the telegraph instrument: the wire coming from the zinc is attached to a gas or water pipe, or anything that is a conductor which connects with the ground. The wire coming from the carbon is connected with one point of the switch; the other point of the switch is connected with one end of the wire wrapped around the spools, the other end of the wire from the spools is connected with a pipe leading to the ground, as is the wire from the zinc. (Fig. 79.)

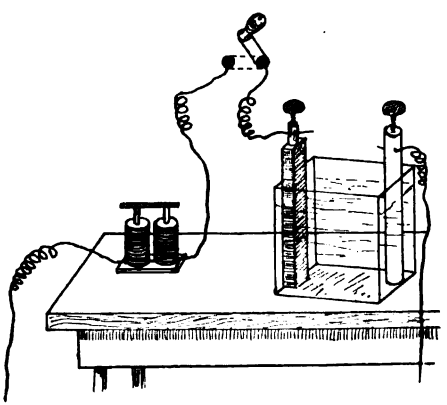

FIG. 79.

A switch is two metal points; on one point is attached a metal bar that may rest on the other point or not, as you wish; the

circuit is completed through the points of the switch, and the pieces of iron become magnetic when the circuit is broken, or, in other words, when the points of the switch are not connected the pieces of iron lose their magnetic attraction.

The explanation is this: the earth contains both positive and negative electricity; the wire from the zinc we know conducts negative electricity and that negative electricity is attracted by the positive electricity of the earth; the wire from the carbon conducts positive electricity; this positive electricity travels over the wire through the switch, through the wire on the spools, and is attracted by the negative electricity of the earth, and thus the circuit is complete.

CHAPTER X.

Electro-Motive Force.

A current of electricity may be affected by the length and thickness of the conductor and by the resistance. By resistance we mean anything which impedes the passing of the current.

The current is affected by,

1st. The length of the conductor. Let us return to our two barrels connected at their bottoms by the inch pipe, page 51. (Fig. 80.) One barrel is full of water and the other is empty. The water will flow from the full barrel into the empty barrel much more rapidly if the pipe connecting them is two feet long than if the pipe connecting them is twenty feet long; and so with the passing of the current of electricity.

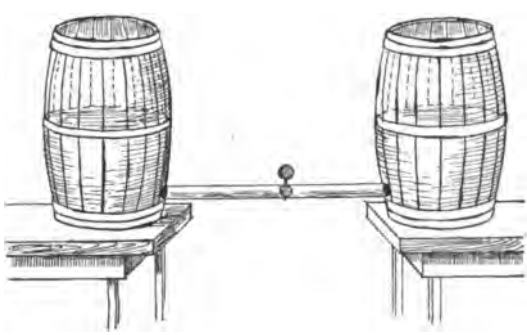

FIG. 80.

2d. The current is affected by the size of the conductor. You know that the water will flow much more rapidly from the full barrel to the empty barrel if the pipe connecting them is four inches in diameter instead of one inch. So with a current of electricity. Let us suppose we have a pipe two inches in diameter coming from the barrel filled with water, and after it has left the barrel, say two feet, the end of the pipe farthest from the barrel

is closed and into the cap closing that end a pipe half an inch in diameter is set; the small pipe being two feet long also. (Fig. 81.) Hydraulic pressure is equal in all directions. If the valve is opened and the water allowed to flow from the barrel into the large pipe, and from the large pipe into the small pipe, the velocity of the water in the small pipe will be much greater than that in the large pipe. This fact has been taken advantage of in electrics. A small wire is set into the circuit between large wires; the velocity of the current heats the small wire to a dull heat, a white heat, or an incandescent glow; depending on the velocity of the current or, in other words (Fig. 82), the height of the water in the barrel.

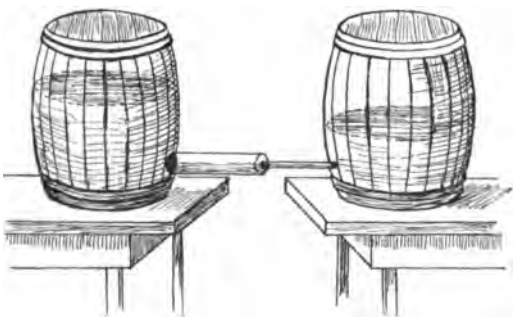

FIG. 81.

3d. The current is affected by anything which interferes with or impedes the passing of the current. Perhaps you will understand this better if you will remember that the water will flow from the full barrel into the empty barrel through a straight pipe connecting the barrels much more rapidly than it will through one having a number of angles, or one in which there are obstructions, such as sand or dirt. Electro-motive force is that which moves electricity through its circuit. In the case of the two barrels, the force that moves the water from one barrel to the other is the hydraulic pressure; this illustrates electro-motive force. Now note this fact—the greater the difference in potential, the greater the electro-motive force; or in other words, the

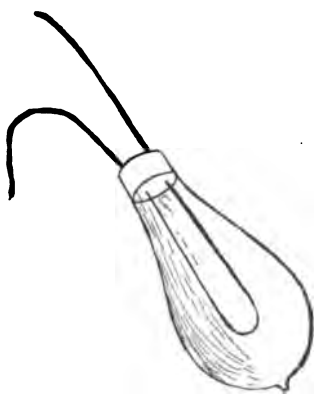

FIG. 82.

higher the water in the full barrel, the more quickly will the water accumulate in the empty barrel. As has already been said, the current of electricity moves in waves. Remembering the experiment of the bricks standing on their ends will make this matter clear.

The strength of the current for therapeutic use depends upon electro-motive force.

Electro-motive force may be modified by—

1st. The nature of the elements.

2d. By the quality of the battery fluid.

3d. The condition of the elements as to impurities.

4th. The number of cells—not the size of the cells.

5th. The length of time in use.

You would not expect to obtain the same amount of electro-motive force from one cell having impure elements that had been used a long time, and a poor battery fluid, as you would from several cells with pure elements and a good battery fluid.

Quantity is the total amount of electricity passing through a circuit in a given time.

Quantity may be increased—

1st. By increasing the size of the elements.

2d. By bringing the elements closer together.

You know that the amount of water that will pass from a full barrel to an empty barrel through a pipe an inch in diameter will depend upon the size of the barrel; and that the closer the barrels are together and the shorter the pipe, the quicker it will pass.

Let me try to elucidate this obscure point. For therapeutic use it is the electro-motive force which is desired, or it is the force which moves electricity through its circuit. Now, remember that this electro-motive force depends upon the difference of potential of the elements; or to return to our illustration, to the height of the water in the barrel. So when we speak of the potential arrangement of cells, we mean cells arranged so as to obtain the electro-motive force, and to obtain this, the collecting plates are connected to the generating plates in this manner: the wire from the carbon of the first cell is connected with the wire from

the zinc of the second cell, and the wire from the carbon of the second cell is connected with the wire from the zinc of the third cell, and so on; leaving at one end of the row of cells, a wire from the carbon, and at the other end of the row of cells, a wire from the zinc; when these two are united the circuit is complete. (Fig. 83.) This is what is known as the potential arrangement of cells, and from them you obtain electro-motive force. You will obtain precisely the same amount of electro-motive force from a cell four inches square as you will from a cell one foot square. It is this electro-motive force that we now mainly use in electro-therapeutics. I believe that the successful development of this agent as a scientific remedy will be in adapting a proper ratio of the electro-motive force and quantity to individual conditions.

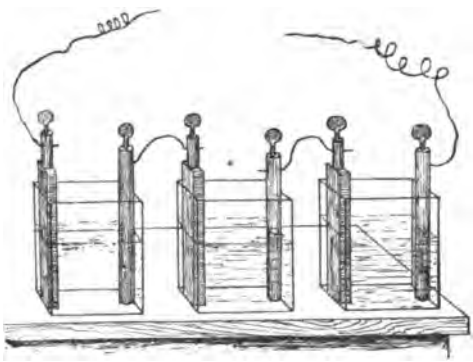

FIG. 83.

In using electricity to obtain heat or light it is not electro-motive force that is desired; it is speed, or, as electricians call it, tension. The tension depends upon quantity, which is the total amount of electricity passing through a circuit in a given time.

As we have a potential arrangement of cells, viz.: the connecting of the generating plate of a cell to the collecting plate of another cell from which we obtain electro-motive force, so we have a quantity arrangement of cells from which we obtain heat and light.

Now note the difference in the connecting of the cells: to obtain quantity all the generating plates are connected, and also all the collecting plates, connecting zinc to zinc and carbon to carbon. (Fig. 84).

This brings us to the consideration of a much studied and little understood subject, viz.: electro-measurements.

Some years ago the following law of electrics was discovered, viz.: the current is equal to the electro-motive force divided by the resistance. It is expressed by the formula C = e / r. This is known as the Ohm law. This law is valuable to the therapeutist who does original work, as it will materially aid in explaining the differences in therapeutic effect of different batteries, and also enable him to regulate the current in such manner as to produce the desired action. In ordinary practice the law is of very little use. Those who use this law will become thorough electricians.

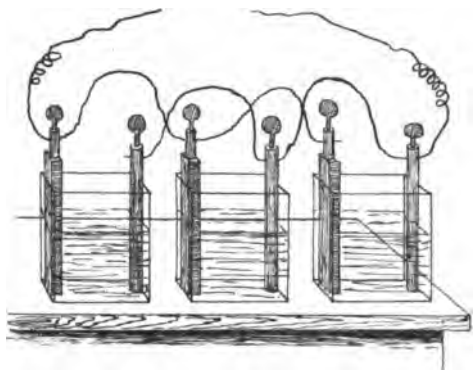

FIG. 84.

In mechanics things are measured by the foot and inch, and the unit of measure is the inch. In weight things are estimated by the ounce and pound, and the unit of weight is the ounce. In estimating quantity things are measured by the bushel, peck, quart and pint, and the unit of measurement is the pint. In our currency we count things by the dollar and cent. In electricity we have units of measurement also; we call the unit of electro-motive force, a volt. Each cell possesses so much electro-motive force, which we call a volt, and if we have a battery of twenty cells we say it possesses a voltage of twenty volts. The unit of resistance we call an ohm.

If two elements of a cell be connected by 250 feet of pure copper wire, one-twentieth of an inch in diameter, and it is possible to detect a current, while if 300 feet of wire be used and it is impossible to detect a current, this cell has a resistance of one ohm; that is, the voltage or electro-motive force is just sufficient to overcome one ohm of resistance.

A Coulomb is the unit of electrical quantity and it represents the quantity of electricity transmitted in one second through one

ohm by one volt; or it means the quantity of electricity passing over 250 feet of pure copper wire, one-twentieth of an inch in diameter, by an electro-motor force of one cell or volt.

An Ampere is the unit of the electric current; it is equal to the current of one coulomb per second, and is due to the electro-motive force of one volt working through the resistance of one ohm. A milliampere is one one-thousandth part of an ampere.

CHAPTER XI.

The Faradic Current.

Galvanism, you will remember, is that form of electricity set free by chemical action in a cell. In order to have a galvanic current of electricity we found it was necessary for the elements to be destroyed at different rates in the solution, and the one that was destroyed the most rapidly set positive electricity free.

You know that this electricity always passes in one direction, that it is a continuous current.

Your attention has been directed to a continuous current obtained directly from the cell; I desire now to call your attention to an interrupted current which is obtained by induction from the continuous current. This is called the faradic or interrupted current.

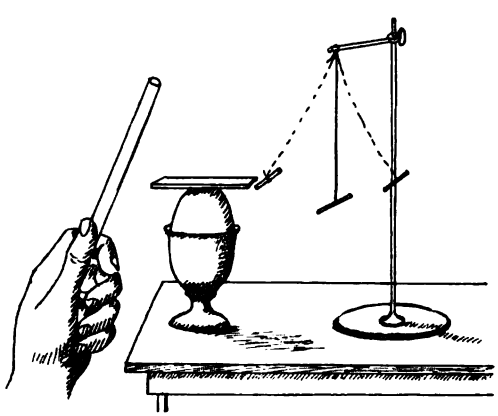

FIG. 85.

The proper therapeutical application of these two currents depends in a very great measure upon a proper understanding of them.

Returning to one of our early experiments, page 23, place the pine stick upon the top of the egg-glass and suspend a straw by a silk thread near one end; rub the glass tube with a silk pad and bring

it to the other end of the pine stick, but do not touch it, and you will observe the straw fly to the end of the stick, touch it, and then it is repelled. (Fig. 85.) Discharge the straw by touching it, take away the tube and you find that the stick contains no electricity. The stick did not touch the tube at any time,

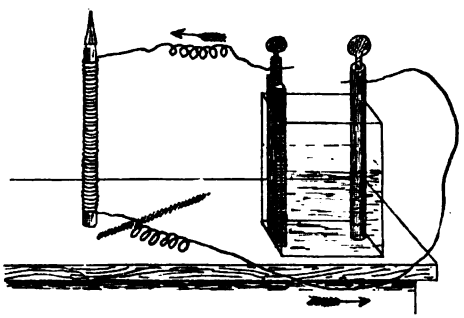

FIG. 86.

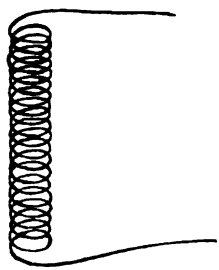

FIG. 87.

yet there was electricity in the stick. From your previous experiments you know that the electricity in the stick is induced by the free electricity on the tube.

Take a long piece of insulated wire and wrap it around a lead-pencil; connect one end with the wire from the zinc, and the other end with the wire from the carbon of a cell. (Fig. 86.) You know there is a continuous current of electricity passing over this wire, and that it is passing from the wire that comes from the carbon plate through the coil and back to the zinc plate.

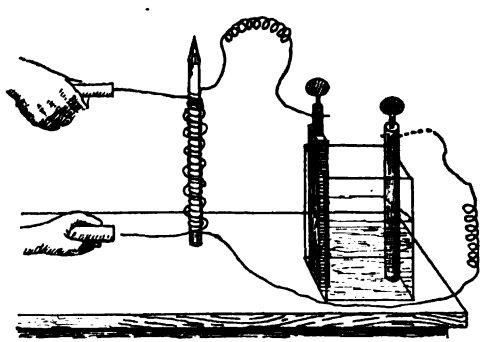

FIG. 88.

Make a coil of insulated wire larger in diameter than the first coil (Fig. 87), loosening the end of the wire of the first coil connected to the zinc, slip the wire through the second coil and place the second coil immediately over the first coil (Fig. 88); notice

particularly that the second coil is not attached to the first coil in any way. The first coil is composed of insulated wire, as is the second coil; the two ends of the second coil are connected with handles, and while you hold the handles your assistant will touch the end of the wire of the first coil to the zinc. The instant the wire is touched to the zinc a shock is felt, but only for an instant; take the wire away from the zinc and the same sensation is felt for an instant only. Now make and break the current quite rapidly and the sensation is still more perceptible.

Slipping out the pencil from inside the first coil, put in its place a permanent steel magnet; making and breaking the current, the person holding the handles finds the current strong enough to produce a decided impression upon his muscles. (Fig. 89.)

Two coils of insulated wire; the first one, which is called the primary coil, is attached to the elements of the cell; the second coil is wrapped upon the first coil (but not connected with it and not connected with the elements of the cell, but has its ends free) and is called the secondary coil. We find that a current of electricity is obtained from this secondary coil when the circuit of the primary coil is broken or closed. This electricity in the second coil is induced electricity from the first coil; but remember that the current is only induced in the second coil when the circuit in the first coil is made or broken. This electricity in the second coil is known as the interrupted or faradic current, named from its discoverer, Faraday.

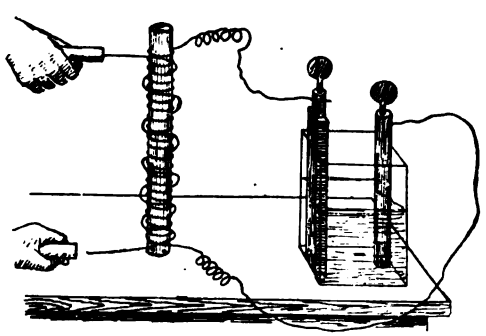

FIG. 89.

You also observed when the magnet was placed in the center of the primary coil that the induced current in the secondary coil was greatly increased.

It is necessary then, in order to have a faradic current of elec-

tricity, to have two coils of insulated wire, the second wrapped upon the first; the first coil connected with the elements of the cell, and the current must be interrupted.

Figure 90 is a coil of insulated wire wrapped about a bar of soft iron. Now you know that if a current of electricity pass over the wire that is wrapped around the soft iron bar, the bar will become and remain an electro-magnet, possessing all the properties of magnetic attraction and magnetic induction as long as the current is passing through the wire around it; but the instant the circuit is broken, that piece of soft iron loses its magnetic properties and becomes simply a piece of iron, but instantly resumes those properties as soon as the circuit is completed in the wire about it. One end of the wire around the bar of soft iron is connected with the wire from the carbon of the cell; the other end of the wire is connected to a brass post to which a steel spring is attached; one side of this steel spring rests upon a screw point. The post through which the screw passes is connected to a wire. Now if you connect this wire to the zinc in the cell you have a complete circuit.

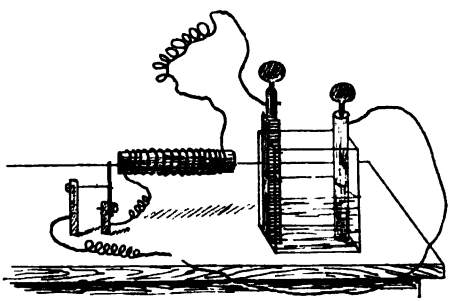

FIG. 90.

Let us see if this is true. The positive electricity passes over the wire from the carbon round and round the coil out of the other end of the wire from the coil into the post to which the spring is attached, along the spring to the screw point, down the post to the wire, from the wire to the zinc in the cell and through this fluid to the carbon; therefore it is a complete circuit. But as soon as the wire is connected to the zinc plate and the circuit is complete the bar of soft iron, around which the coil is wrapped, becomes an electro-magnet; and its magnetic attraction is greater than the stiffness of the steel spring, so the end of the steel spring is drawn to the bar of soft iron. (Fig. 91.) Now what

occurs? As soon as the bar of soft iron becomes an electro-magnet and attracts the steel spring, that instant the steel spring leaves the end of the screw point with which it was in contact and the circuit is broken; the steel has been attracted to the end of the bar of soft iron, but by attracting it the circuit was broken and the bar of soft iron ceased to be a magnet; its attraction for the steel spring was lost. The spring flies back to the screw point, the circuit is complete, and the bar of soft iron again becomes a magnet and again attracts the steel spring, only to again break the circuit and lose its power of attraction. In this we have an automatic arrangement to make and break a circuit; it is known as a rheotome.

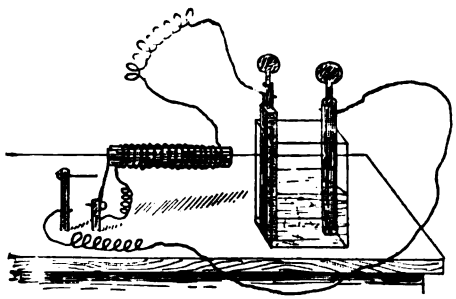

FIG. 91.

You will remember that it is necessary to have an interrupted primary current in order to obtain a secondary current by induc-

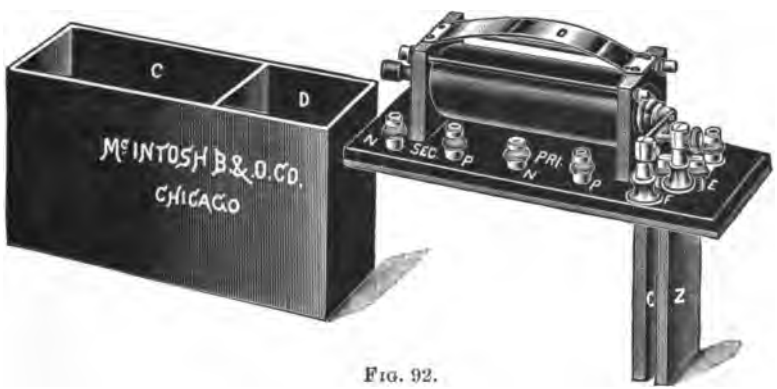

FIG. 92.

tion. Around this first coil has been placed a second coil; as the rheotome makes and breaks the current, we obtain an interrupted current in the secondary coil.

You observed in your first experiment that the secondary current was very much increased by placing a magnet on the inside

of the primary coil; the bar of soft iron in this instrument takes the place of the magnet, as it is a magnet when the current is completed.

As you will observe, the bar of soft iron has a brass cover which may be slipped over it or removed; when it is pushed all the way in, it entirely covers the bar of soft iron. It does not prevent its becoming a magnet, but it prevents its influence from being felt upon the current in the coil. It is very evident that the further out this slide is drawn the more of the magnet there will be exposed and the stronger the current in the secondary coil. This is known as the helix, and the brass cover is the helix shield.

FIG. 93.

We can have a third coil of wire around the second and obtain from it a current of electricity by induction from the secondary coil.

Now note this in particular: a faradic current of electricity is an induced current obtained from an interrupted galvanic current. The instant the circuit is complete, there is a current of electricity produced in the secondary coil by induction, passing in the opposite direction; when the circuit is broken, there is again a current produced in the same manner in the secondary coil, but running in the same direction as that in the primary coil. In other words, the faradic current is an alternating current; one instant it is running in one direction, the next instant in the opposite. Do not forget this point, as we will have occasion to use it.

Faradism, then, differs from galvanism:

1st. It is not obtained by chemical action direct but by induction from the primary current.

2d. The galvanic current always passes from the positive to

the negative pole, while the faradic current passes one instant one way and the next instant the other way.

Thus far in your study you have obtained electricity by friction, as with the glass tube, the sealing-wax, the electrical machine, and by chemical action in a cell. There is still another way in which electricity may be obtained. Figure 93 shows a common horse-shoe magnet. At its end, set so as to revolve within the magnet, are two spools wrapped with insulated wire. If the crank is turned the spools revolve, and, as you will perceive if you take hold of the handles, a current of electricity is

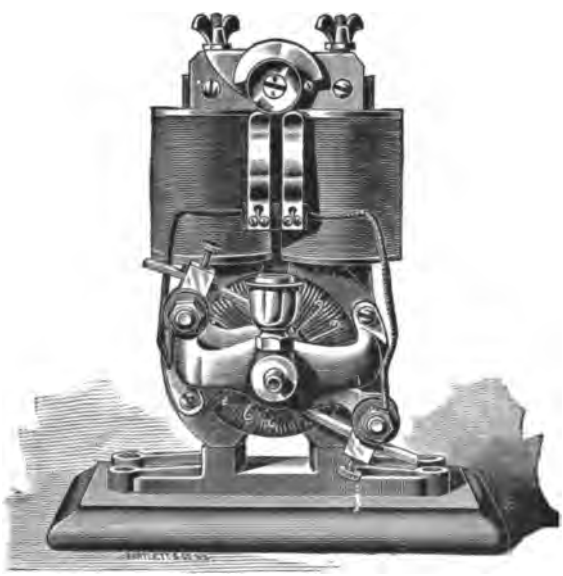

FIG. 94.

set free. The spools have revolved, they are covered with insulated wire, and the electricity is set free by magnetic induction through the insulated wire. This is known as a magneto-electric machine.

Figure 94 is quite a different looking instrument. It is composed of powerful electro-magnets or permanent magnets; set so as to revolve within these magnets is a coil of insulated wire. This is a dynamo or power machine. Through this machine the

electric light, the electric car, and, in fact, all the powerful work of electricity is accomplished. The coal heats the water into steam, the steam moves the machinery of the engine, the machinery runs the armature which is the insulated wire, and a current of electricity is set free. This electricity is transformed force. In this department there is yet much to be done; much of the force is wasted in transforming the coal into electricity, but the time will come, undoubtedly, when electricity will be obtained directly from the coal, and when heat as well as light will be obtained from "buried sunlight"—coal—by means of electricity.

It is not within the province of this Manual to take up the minutia of either the dynamo or the electric motor. I simply wish to draw your attention to the fact that electricity may be set free from magnets by either revolving the magnets around the insulated wire, or the insulated wire within the magnets, or close enough to the magnet to obtain its magnetic induction.

CHAPTER XII.

Various Kinds of Cells.

Let me call your attention to a few points in regard to detecting the presence of galvanic electricity. You have connected up a series of cells and you wish to know whether or not you are obtaining electricity from them. Bring the two ends of the wire together and rub them against each other and you will obtain a spark; better still, hold one end of the wire against a piece of carbon and scrape the other over the carbon and you obtain a spark. (Fig. 95.)

Bring the ends near the needle of a compass. You know what phenomenon will occur if galvanic electricity is present.

We have studied the manner of setting electricity free; we have watched its phenomena and made ourselves familiar with some of its laws, and are now ready to take up for consideration its action upon the human body in health and disease. Before we do this, however, let us consider the different kinds of cells and batteries, the manner of connecting them and the different appliances necessary to the intelligent use of electricity.

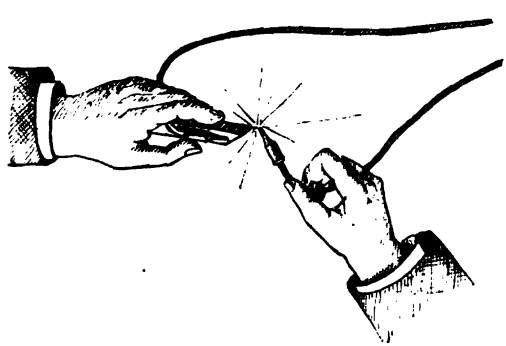

FIG. 95.

We divide cells into two kinds, viz.: the wet or liquid and the dry cell. Of the wet cells, Figure 96 is the one known as the

gravity cell. In this cell zinc is used for the generating plate and copper for the collecting plate; sulphate of copper is the salt

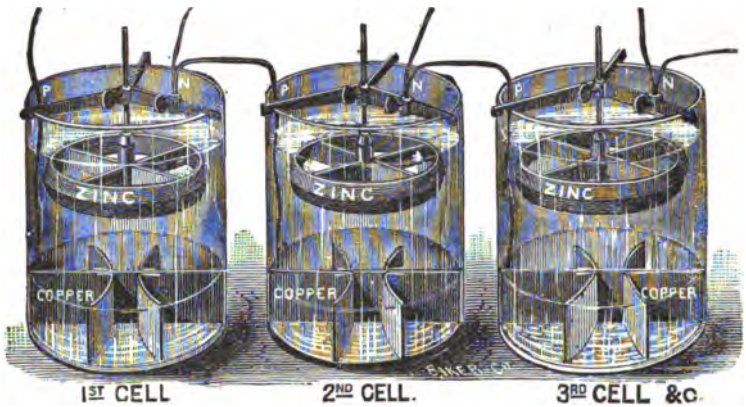

FIG. 96.

used in making the acid solution. This cell gives good satisfaction and requires very little attention; it has two objections, however; it is very large, taking up a great deal of room, and is a very dirty cell. These cells have been almost discarded.

FIG. 97.

Figure 97 is known as a Leclanche cell; in it the zinc is used for the generating plate, and for the collecting plate there is a porous cup filled with carbon. This cell has a high voltage. The

solution is composed of six ounces of sal ammoniac and water, and let me caution you that in any of these cells never use anything but the purest sal ammoniac.

The greatest objection to the Leclanche cell is the fact that the porous cup will become obstructed, and a short circuit being formed within the cell they require boiling in water to clean them. It is, however, a very satisfactory cell.

Figure 98 is known as the Laclede cell, and in it zinc is used for the generating plate and a large piece of circular carbon for the collecting plate. The zinc passes down through the center of the carbon; on the lower end of the zinc is a rubber ring.

Rubber, you will remember, is an insulator; the object of the rubber ring is to prevent the zinc from touching the carbon. This

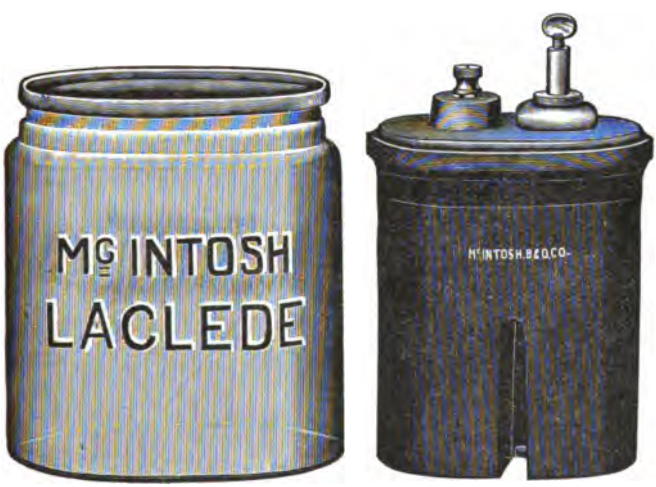

FIG. 98.

is a good cell, the greatest objection being the closeness of the zinc to the inside of the carbon. Crystals will form between the zinc and the inside of the carbon; the cell is then short-circuited and continues to act until the zinc is destroyed or the fluid exhausted, and it is then said to be polarized. The Laclede is a comparatively cheap cell and one which, with ordinary care, will give good service.

Figure 99 is called a Law cell; it does not differ materially from the Laclede, but is more expensive.

Figure 100 is called the diamond-carbon cell and is composed of a number of pieces of carbon arranged in a circle, and in the center of the circle the zinc is protected by a rubber ring insulator. This perhaps is the most universally used cell to-day; it is cheap, durable and reliable, and the carbons are easily cleaned; all they need is rinsing in hot water. With ordinary care these cells will give good service for one or two years. They are charged with

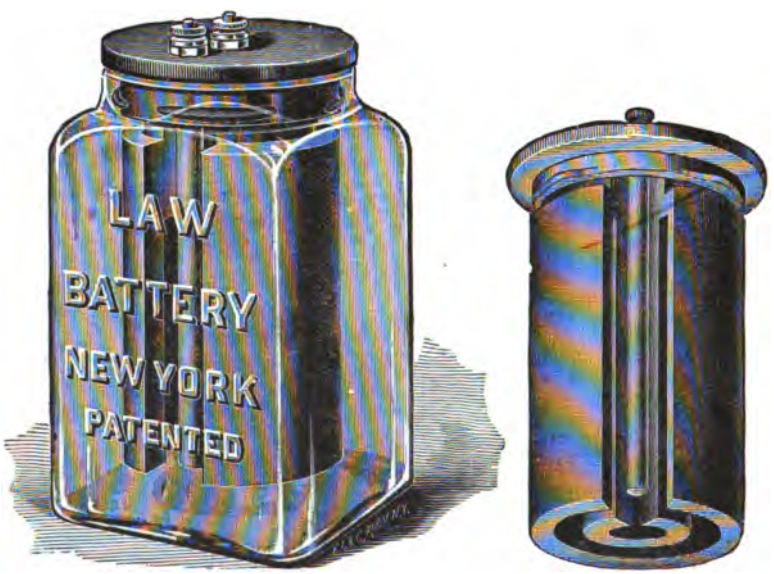

FIG. 99.

six ounces of commercial sal ammoniac and water. Let me call your attention to this little point: if you think your battery-fluid is growing weak and you wish to add some sal ammoniac, never attempt to put it in the cell without first removing the zinc and carbon plates, for a small amount of sal ammoniac adhering to a zinc or carbon plate may form a nucleus for a crystal which will short-circuit the cell.

Your cells should be put in a cool place, and if you wish to obtain from them the best results seal their tops with paraffin or

bees-wax; look at them once in seven or eight months, and if the water has evaporated add a little more to them. Don't put them in an inaccessible closet or cellar, but put them on shelves or in a cabinet. They may not look as nice as you would like to have them, but they will do you no harm and will certainly give you better service.

These cells of which we have been studying are those used for office batteries. For portable batteries the cell most commonly

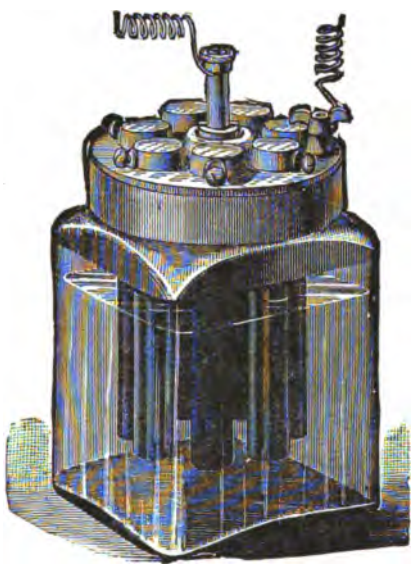

FIG. 100.

used is shown in Figure 101. It is a zinc and carbon cell; the fluid used is composed of water, sulphuric acid, bi-chromate of potash and bi-sulphate of mercury. The manufacturers claim that these batteries are made so that they will seal up and not leak, but if you wish to carry such a battery any distance, do not trust to carrying the fluid in the cells, carry it in a jug having a wooden cork, and when you have used the battery pour the fluid back in the jug. It will cause some trouble, but it will save the bottom of your buggy, the bottom of your battery and perhaps your clothes.

Much was expected of the dry cells; they are small and compact, and it was hoped that they would surpass the wet cells. As yet there is no dry cell made that will begin to equal in durability and service the diamond-carbon, the Laclede, or the Leclanche.

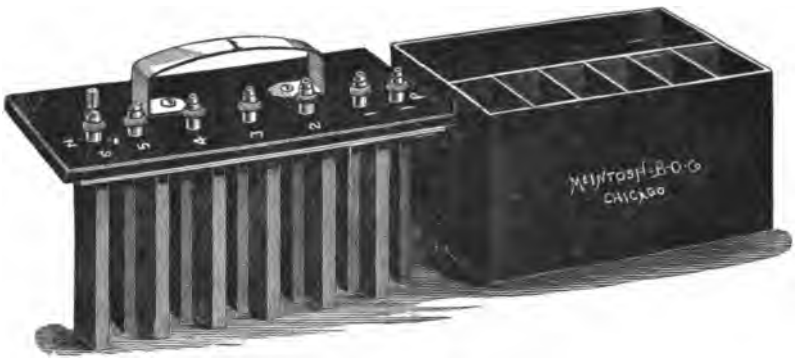

FIG. 101.

The most of these dry cells are composed of chloride of silver. (Fig. 102.) Now do not misunderstand me; I am not condemning the chloride of silver cell, but it is more expensive, more easily

FIG. 102.

polarized and no more durable, nor does it give as good service as the others. For faradic work, where you wish to obtain a faradic current for a short time, the chloride of silver cell will give you

good service. My experience has been, however, that the most reliable are the liquid cells. There is no doubt but that ultimately there will be made a serviceable dry cell; some that are on the market now may be serviceable, but I have no knowledge of them.

CHAPTER XIII.

Batteries and Electrodes.

We have several kinds of batteries, viz:

1st. The simple faradic battery, which is nearly always a portable or pocket battery.

2d. A combined faradic and galvanic portable battery.

3d. The office battery.

4th. The storage battery.

5th. The cautery battery.

6th. The electro-magnetic battery.

The electro-magnetic batteries we can dismiss in a few words. They are absolutely useless in therapeutics; never under any circumstances buy one, and never let your patients use one and say they are taking electricity. My experience has been that the use of such batteries has done the cause of electro-therapeutics more harm than good.

There are two kinds of batteries exclusive of the cautery and the storage battery. The first which we will consider is the portable battery: Portable batteries are not as reliable as office batteries, yet you can do good work with them. If you can afford it buy an office battery in preference to a portable one; although a portable faradic battery is at times a convenient thing to have. If you have a portable battery keep it scrupulously clean; after using it always empty the fluid into the jug, rinse out the cells and wash off the plates.

In fully ninety-eight per cent of all the cases where electricity is applicable the patient will be able to come to your office for

treatment. Don't buy a portable battery until you are compelled to, and don't use it unless it is utterly impossible for your patient to get to your office.

The second kind of battery that we will consider is the office battery. Of these there is a great variety ranging in price from

FIG. 103.

$35.00 to $200; but as economy is usually a necessary factor I (Fig. 103) will describe, mainly, the economical batteries.

A good battery will consist of

1st. The cells, which should be from fifteen to thirty in number; twenty-five being a good number. If you select either the diamond-carbon, the Leclanche or the Laclede you will be satisfied. My preference is for the diamond-carbon, for reasons already given.

2d. Is the switch-board (Fig. 104), which consists of several buttons numbered from 0 to 25 or 50 and a switch which has

a double bar, and is known as the double switch or cell selector, and a pole changer. On the switch-board, which, by the way, is made of polished hard rubber, is a faradic coil, and on one side (Fig. 105) two binding posts, as they are called. These switch-boards may be plain or very elaborate; but the plainer the board, the less on it, the better satisfaction it will give.

As you wish to set up your battery you must have some suitable place for the cells and a suitable stand for the switch-board to rest upon. You may put the cells in a closet or on shelves,

FIG. 104.

but if you have them under your switch-board in a cabinet they will give you better satisfaction; a common stand with shelves will do very well, but the nicest and most convenient is a full-cabinet sewing-machine case.

You wish to connect up your battery for use; therefore, to each cell you have added six ounces of commercial sal ammoniac and filled them with water; turning over the switch-board, you observe pins having a hole in each and a screw in their ends. Commencing with the first cell, you take a piece of insulated copper wire; bare the end of the insulation for an inch and a half, fasten it to the carbon of the cell and run it to the switch-board. This wire is attached to the pin on the under surface of the

switch-board that is marked O on the top; in attaching this to the pin, strip the wire of its insulation for an inch and a half and bend the bared wire upon itself as shown in Figure 106. The reason

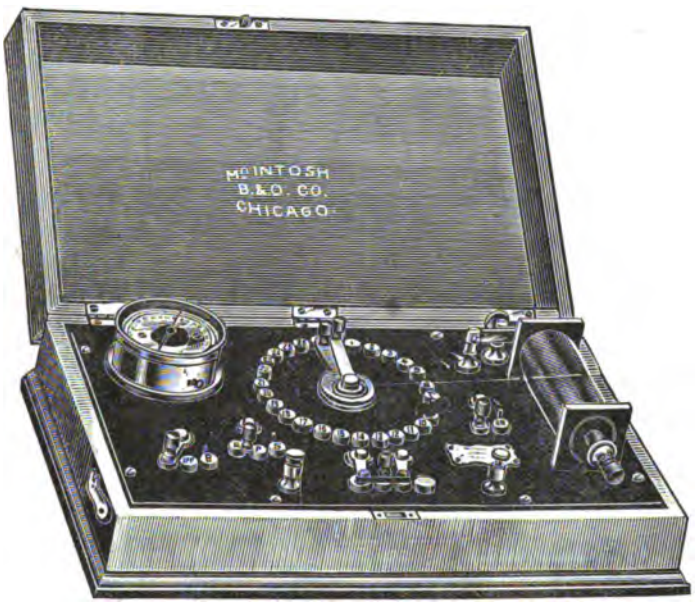

FIG. 105.

for this is that it gives a better surface for the screw to fasten to; turn the screw upon the wire tightly. To the zinc of the cell attach a long wire and a short wire, bending the ends of the wires in the same manner as formerly; in fact, wherever a screw is to

FIG. 106.

come in contact with a wire bend the wire upon itself if possible. The long wire from this zinc you connect with the pin marked I, on the under side of the switch-board.

You have one cell in the circuit; that is, when one point of the switch rests upon O and the other point upon I the circuit is complete with one cell, through the wires, the buttons and the

points of the switch. Now, taking the second cell (remember that this battery is for therapeutic use; it is electro-motive force which you desire, and to obtain it you must connect the cells alternately), so the short wire from the zinc of the first cell is connected with the carbon of the second cell. To the zinc of the second cell connect two wires, a long and a short one; the long wire is run to the switch-board and connected to the button marked 2. Now, when one arm of the switch is upon O and the other upon 2 you have two cells in the circuit.

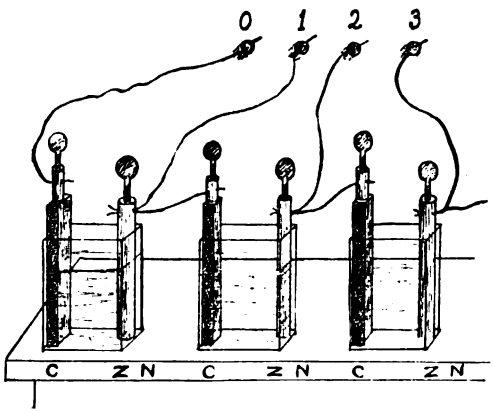

Fig. 107.

The short wire you connect to the carbon of the third cell and to the zinc of the third cell you attach two wires, a long and a short one (Fig. 107); the long one is connected to the pin beneath the button marked 3, so that when one point of the switch rests upon O and one upon 3 you have three cells in the circuit; and if one point of the switch rests upon 2 and the other upon 3 you have one cell in the circuit. In this manner you connect up all your cells; from the last cell you carry only one long wire from the zinc. If your buttons should increase one button at a time to 20, and from

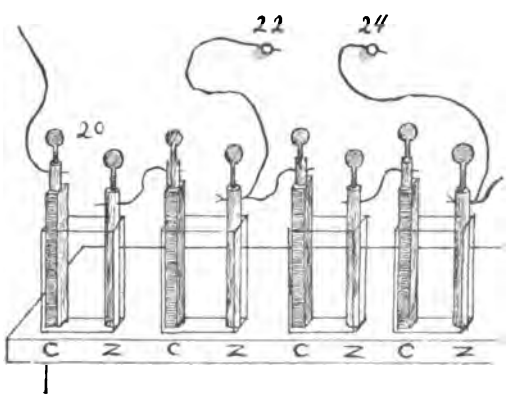

Fig. 108.

20 to 30 two at a time, you connect the buttons to 20 as I have described.

The short wire from the zinc of the twentieth cell you connect with the carbon of the twenty-first cell, and to the zinc of the twenty-first cell you connect only a short wire; this you connect with the carbon of the twenty-second cell, and to the zinc of the twenty-second cell (Fig. 108) you connect two wires, a long and a short one. The long wire you connect to the under side of the pin marked 22. You could connect them up four cells at a time in a similar manner.

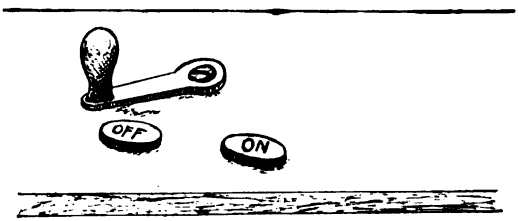

FIG. 109.

I have said nothing about connecting the cells to the binding posts or to the faradic coil, for every switch-board that you buy will have these connections already made, and all it will be necessary for you to do has been described.

On every switch-board you will find two small switches besides the one we have already described, one having two buttons and the other three. The one with two buttons is marked "on" and "off." (Fig. 109.) When the point of the switch rests upon the button marked "on," and the cells are thrown into the circuit the faradic coil will work. The switch with the three buttons has one button marked G, one marked P, and one marked S. (Fig. 110.) When the point of this switch rests upon G, and the point of the other switch rests upon "off," and the cells are thrown into the circuit, you will obtain a galvanic current from the binding posts. When the point of the switch is upon "on," and the point of the other switch upon P and the

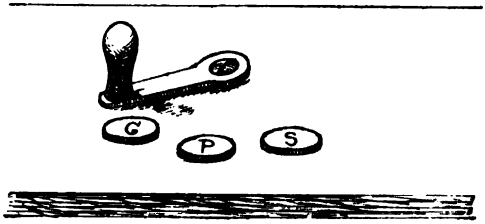

FIG. 110.

cells in the circuit, from the binding posts you will obtain a primary faradic current; if the point of the switch is upon S, you will obtain a secondary faradic current.

Fig. 111.

Your battery is now ready for work, but in order to apply the electricity it must be conducted from the binding posts to the

Fig. 112.

patient. This is done by means of conducting cords; they are composed usually of fine wire covered with an insulation of silk.

Fig. 113.

Insulated copper wire makes good conducting cords, but the silk-covered cords are the most used. (Fig. 111.) You, however,

still lack one thing in order to be able to use your current, viz.: instruments known as electrodes. Every battery is accompanied by a pair of handles like those shown in Figure 112. These handles are nearly always covered with sponge; they are sometimes covered with chamois skin and sometimes with carbon.

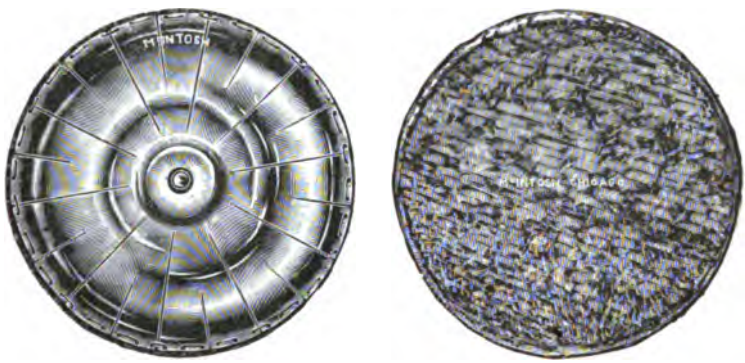

FIG. 114.

Don't use sponge for a covering; it is dirty and a poor conductor. Cover the ends of your handles with a thin layer of absorbent cotton; it can be changed for each patient, and you have an absolutely clean electrode. But these handle electrodes will not

FIG. 115.

answer all purposes, and other electrodes are necessary. If you should buy an electrode for every condition you treat it would require a small fortune, but it is entirely unnecessary.

You should have one large zinc plate six by twelve inches, another six to ten inches in diameter (Fig. 113), and if you can

afford it a circular abdominal electrode which is covered with spongiopiline (Fig. 114); and if you wish a still more expensive abdominal electrode, procure a Martin's. The Martin's abdominal

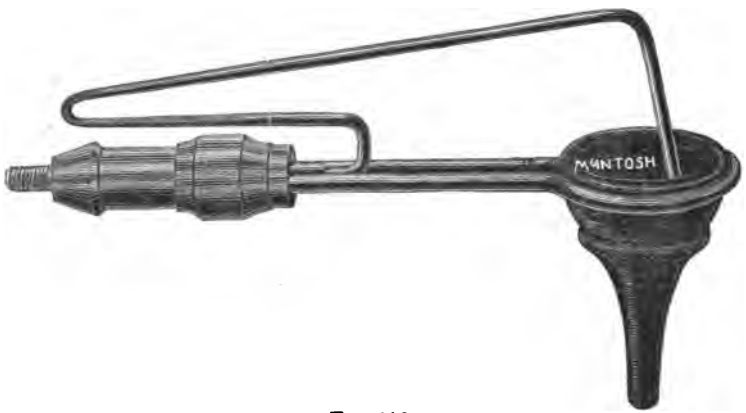

FIG. 116.

electrode is composed of a concave pan, over the top of which is stretched an animal membrane. (Fig. 115.) The pan is filled with water through an opening left in it, and the membrane

FIG. 117.

becomes a conductor. This is a good electrode when it does not leak. If you have one, always leave it full of water, for if you do not the membrane will dry and crack.

To use the spongiopiline electrode, thoroughly wet the spongiopiline in warm water. If you wish to apply the zinc plates to the body, cover them with towels which have been wrung out of hot water.

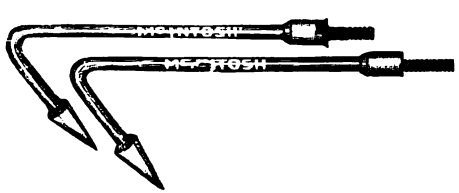

FIG. 118.

If you wish to use the handles, thoroughly wet the absorbent cotton or sponge that covers them in hot water; and it will be a better conductor if you add a little salt. These electrodes are for use on the surface of the body.

Figure 116 is an electrode made to use in the ear.

Figure 117 is an electric brush.

Figure 118 is another electrode which has a very small point.

Figure 119 is an electrode with a long handle.

There are almost as many different kinds of electrodes as there are men using them; but the zinc plates and the spongiopiline

FIG. 119.

electrodes, together with the pair of handles, will answer for all ordinary and most extraordinary occasions in the treatment of the surface of the body and the parts reached through the surface of the body.

For urethral work, your steel urethral sounds will answer the purpose in the treatment of male patients. For the treatment of

FIG. 120.

women and the diseases peculiar to them, you need, first, a vaginal electrode; a bent one like Figure 120, not a straight one. For female urethal and intra-uterine work that is done with a faradic

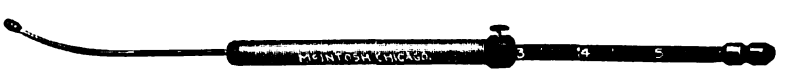

FIG. 121.

current, your graded uterine sounds will answer the purpose better than anything else.

For intra-uterine work with the galvanic current you need a platinum electrode, one of which is shown in Figure 121.

Figure 122 is an electrode which has two points and is used

when you wish to have both poles within the uterus; which, however, is very rare. If you can afford to have only one of these electrodes, get the single platinum electrode.

Figure 123 is a little instrument to which I wish to call your attention; it is called a milliampere-meter. An ampere, you will remember, is the unit of current, and a milliampere is the thousandth part of an ampere. This little instrument is composed of

FIG. 122.

two needles; the under needle points north and south; the upper points east and west; and you will observe that it has two readings, a short scale and a long scale; the short scale measuring from one to twenty milliamperes, and the long scale measuring from one to one thousand milliamperes.

The directions for placing a milliampere-meter in a circuit will accompany each instrument. If you can afford a milliampere-

FIG. 123.

meter at the beginning have it upon your switch-board. A milliampere-meter is not absolutely necessary, but the work done with

one is much more satisfactory than that done without it. You will remember that a milliampere-meter is never to be used with a faradic current.

The little instrument shown in Figure 124 is known as a rheostat, and is one of the luxuries of the electrician. Its use is this: You wish to use a galvanic current; one end of the circuit is attached to the plate, which, you will observe, is so arranged that it can gradually drop into the water; the other end of the current is attached to the water; now switching on all the current with the plate out of the water, you allow it to gradually drop into the water. In this manner a current of high voltage may be

FIG. 124.

used without any sudden interruption, and with much less inconvenience and pain. There are several kinds of rheostats, and any of them are good. Observe one thing in regard to their use, however; don't allow the water to stand too long in them without being changed.

As to the care of your battery, see that the switch points are always left on the "off" button; keep the connections clean; keep your battery closed when not in use; occasionally look over the nuts and screws and see that they are all tight. If anything gets

wrong with your circuit follow around with your double switch until you see what cells it is between, then look it up. As to the care of the cells you have been already instructed.

We will leave the study of cautery and storage batteries until we come to consider the subject of electro-cautery.

In reference to a static machine, I will say this much: I have never seen a case where electricity was applicable that static electricity would do better or as well as the galvanic or faradic currents. If you wish to use one, you will find extensive directions in Beard and Rockwell's work on electricity.

This will complete what I have to say upon the subject of electro-physics and batteries.

CHAPTER XIV.

Electro-Physiology.

Electro-physiology is the science which teaches us the laws of animal electricity and the phenomena produced by electricity upon the human body. In our work with electricity it is necessary for us to learn sufficient facts in regard to its action upon the human body to enable us to work intelligently with it. It is possible to use electricity to relieve pain, cure some forms of paralysis, obtain its tonic, stimulant and sedative effects upon the human body, and yet know nothing of the facts concerning its action; when it is applicable or when it is not. Any one can hold an electrode upon a paralyzed muscle, and if the paralysis be due to purely local conditions good results will be obtained; but should the paralysis be of central origin such treatment would do no good. We must learn, then, when to use it and when not to use it; and above all things we must learn not to abuse it. Let us try to master at least the principal facts in connection with its use. Do not be content with curing the symptoms (for symptoms, you know, are but the manifestation of actual pathological change or functional derangement); but by the aid of electricity study disease.

As yet electro-therapeutics is not based upon electro-physiology. To-day the therapeutical application of drugs in diseased conditions depends upon their action on the human body in health. Thus far the application of electricity to the treatment of diseased conditions does not depend upon the action of electricity upon the body in health. Electro-therapeutics and electro-physiology are separate and distinct sciences. Some attempts have been made to base electro-therapeutics upon electro-physi-

ology, but as yet with indifferent success. Our indefinite knowledge as to what electricity and nerve force are, and our poor understanding of the complex subject of nutrition, has prevented us so far from applying electro-physiology to any great extent to electro-therapeutics. Electro-physiology is a science of experiment, while electro-therapeutics is a science of experience.

However, it is necessary for you to study the action of electricity upon the living subject, and the best time to do this is while you are applying it to both healthy and diseased parts. Watch its action upon voluntary muscles, the motor and sensory nerves, the effect produced upon the nerves of special senses, and particularly its effects upon nutrition.

To obtain the action from a drug it is necessary that the drug be absorbed; and although the drug may have a special action upon a certain part of the human body, it also, to some extent, acts upon the entire body. Not so with electricity. It may be applied directly to the part affected, and it is not necessary for its action to be felt upon any other portion of the body. In this respect it is superior to drugs. Do not misunderstand me, however; I do not wish to say that electricity will take the place of drugs, but I do say that there are cases where drugs will not act and electricity will. Let us study briefly some of the actions of electricity upon the human body:

1st. The action of static electricity upon the skin. As you perceived in your experiments with the static machine, it produced a pricking, stinging sensation. If you use a wet electrode it acts upon the deeper parts as well.

Faradic electricity causes, first—changes in circulation. At first there is anemia, which is due to the contraction of the arterioles, which contraction is due to the action of the faradic current on the vaso-motor nerves. This anemia lasts only a short time, when we have the second effect, which is hyperemia; this is due to the dilatation of the arterioles, which is the result of the secondary effect of the current upon the vaso-motor nerves. The third effect of the faradic current is pain. Pain is an unnatural or abnormal vibration over a nerve. The faradic current produces pain by irritating the sensory nerves and producing an

unnatural vibration over them. Remember this: the more rapidly the current is interrupted the greater the effect upon the sensory nerves.

In our study of the faradic coil we learned that faradic electricity was induced; and that the direction of the current, when the circuit was made, was from positive to negative; and when broken, from negative to positive. Practically there is no difference in the action of the positive and negative poles of a faradic current; for, strictly speaking, it has no poles; but, nevertheless, (and I am not able to explain it to you, nor will I make the attempt) the faradic current obtained from the negative pole produces more of a stinging sensation upon the skin than that obtained from the positive pole. Some parts of the skin are more sensitive to the effects of electricity than others; this is due to the fact that in some parts the skin has a more liberal supply of sensory nerves, and certain parts are better conductors than others. If the faradic current be applied over a bone—as the anterior edge of the tibia—it produces greater pain because the skin is thin in that locality, and the bone is a good conductor. The faradic current enters the body from the surface through the glands of the skin.

The action of the galvanic current upon the skin is to cause a burning sensation at both poles, which will increase in proportion to the strength of the current and the length of time applied. A light current produces a sensation like a mustard plaster when the mustard has been mixed with flour so it cannot blister. A strong current produces an effect similar to that of a hot iron. At the positive pole the skin becomes pale or anemic, then red or hyperemic, with a mild current. With a strong current, beneath the electrode there is a white spot, while around this is a red circle. At the negative pole there are the same results, only the hyperemia comes more quickly and lasts longer. Practically there is the same action at the two poles, but different in degree.

As to the chemical effects of the galvanic current: At the negative pole there will be a small vesicle or blister containing an alkaline fluid, and this blister will be difficult to heal. At the positive electrode or pole there will be a blister but it will not

appear as soon, and around the blister the skin will present the condition known as goose flesh. This blister at the positive pole will contain an acid fluid which may corrode your electrode. With a mild galvanic current you will obtain but little chemical action. The probabilities are that there is some chemical action obtained from the faradic current, but what it is we do not know.

Study these facts carefully, for they will enable you to use electricity intelligently.

We wish to consider a little more in detail the effects of electricity on the human body and its action upon the different portions of it. You know that in the cortex of the brain, the posterior part of the frontal lobes and the anterior part of the parietal lobes are motor centers; that these motor centers on the right hemisphere of the cerebrum send ninety-eight per cent. of their motor impulses to the voluntary muscles on the left side of the body; and those centers on the left hemisphere of the cerebrum send ninety-eight per cent. of their motor impulses to the voluntary muscles on the right side of the body. These centers, then, control the voluntary motions of the body. We may stimulate or produce an artificial voluntary action with electricity by connecting these centers in the brain with the muscles they supply.

Electricity when applied to the head produces at first a dizziness. This dizziness is described by many as similar to the sensation that comes just before consciousness is lost when taking an anesthetic.

2d. It produces apparent movements; the patient thinking that the head or body is moving or that objects about them are moving.

3d. It produces a staggering sensation as if about to fall. Let me caution you now to be careful in the use of electricity about the head, particularly the galvanic current. When a strong current is applied over the spinal cord it produces rigid muscular cramps. When applied to the pneumogastric nerve it increases its inhibitory power and by this slows the heart's action, and, if strong enough, stops it. When applied to the sympathetic nerve it increases the heart's action. When applied to the ear it produces a ringing, singing sensation, very much like the action of a

large dose of quinine. When applied to the eye the patient sees flashes of light; these flashes of light are often colored, red being the predominant color. When applied to the tongue, as you have experienced, there is a sharp metallic taste.

Irritability of a nerve is that property by which it responds to a natural stimulant, to an external impression or an artificial stimulant. To illustrate: I desire to move my arm, there being no disease of nerve or muscle; I will to move it, the cells in the frontal lobe of the cerebrum send the order to the cells in the motor centers for the muscles of the arms in the cortex of the parietal lobes. These motor cells originate a motor impulse; it is sent out over the nerves to the muscles of the arm and the movement is accomplished. This is responding to a natural stimulant. If the bottom of your foot is tickled while you are sleeping, there being no disease of nerve or muscle, there is a movement of the foot and perhaps the leg; it is a reflex motion, and is a response to an external impression. If I apply to a nerve or muscle a strong faradic current muscular contraction takes place; this is in response to an artificial stimulant.

During life, nerves and muscles manifest their irritability by performing their natural functions, providing they are not diseased. What we call nerve force may be considered to be the same as heat, light, or electricity; simply a manifestation of force.

A muscle will contract under the influence of electricity in two ways: applied either to its motor nerve or directly to the muscle itself; the difference being that when the current is applied to the motor nerve all the muscles controlled by that nerve will contract; and when to the muscle direct no other muscle is affected. The negative pole produces the stronger contractions, because it is the more irritating.

The galvanic current will produce contraction of muscles only when the circuit is closed; never when opened unless the nerve is diseased, when the contraction may also occur when the circuit is opened. This is a very important point.

In every work published to-day on diseases of the nervous system you will find that the writer in speaking of diseased muscles refers to the reaction of degeneration. I am not going to

enter into the details of the reaction of degeneration, how it is obtained, nor of what diagnostic value it is, but will simply say this: it depends upon this fact; that if you apply one pole of a galvanic current (using ten to fifteen cells) over the muscle, and the other pole to the motor nerve supplying that muscle, the instant the second pole touches the surface over the motor nerve completing the circuit, the muscle will contract; and if the nerve is diseased, the instant the circuit is broken or one of the poles is removed, the muscles will again contract.

Let me illustrate: A patient presents himself to us with the middle and ring fingers of his right hand in a state of atrophy; not only are they atrophied but they are almost completely paralyzed as to voluntary motion. Turning on fifteen cells of a galvanic current and baring the left arm, place the positive electrode on the ulnar side of the fore-arm near the elbow, place the negative electrode over the back of the hand and you will observe the instant the negative electrode touches the surface of the hand there is a muscular contraction. Take off the negative electrode and there is no muscular contraction. In other words, the muscles of the left fore-arm and hand supplied by the ulnar nerve contract only when the circuit is closed.

Now try the right arm; placing the positive electrode in the same position as before, and touching the negative electrode to the surface of the back of the hand (which completes the circuit), you will observe that the muscles contract. Lifting the negative electrode off the surface (which breaks the circuit), you will observe that the muscles again contract. This teaches us that the nerve supplying these parts on the left hand is normal; while the nerve supplying these parts on the right hand is diseased.

Electricity when applied to voluntary muscles not diseased produces immediate contraction; but when applied to involuntary muscles the contraction is slow. For instance: you apply the current over the abdomen and it produces immediate contraction of the abdominal muscles, but the contraction of the longitudinal and circular fibres of the intestines does not occur for several minutes and perhaps hours.

In an open blood-vessel the positive electrode of a galvanic current will produce a hard firm clot; while the negative electrode produces a soft clot. This fact has been taken advantage of in the treatment of fibroid tumors of the uterus.

You had better associate in your mind the positive galvanic electrode as being less irritating and hemostatic, and the negative galvanic electrode as being stimulating and irritating.

As to the effects of electricity upon nutrition:

1st. It is a tonic.

2d. It increases secretion.

3d. It increases absorption.

4th. It increases growth.

5th. The galvanic current destroys bacteria.

In this chapter we have given you a brief outline of the subject of electro-physiology. It does not comprise, however, all that is known of electro-physiology; but if you will remember what you have studied already, you will have sufficient knowledge to enable you to use electricity intelligently as a therapeutic agent.

CHAPTER XV.

Electro-Therapeutics.

In the past there has been a great deal of mystery among the laity over the phenomena produced by electricity and the mystery has not yet been solved. Pamphlets have been printed and scattered broadcast over the country asserting in large type that electricity is life; that it will cure all the aches and ailments to which the human body is heir; that this electric belt or that electric ring will cure a paralyzed arm or cause immediate recovery from acute inflammatory rheumatism. This mystery about the phenomena of electricity has led unscrupulous people and charlatans to use it for their profit. The fact that almost every town has its compound-oxygen quack, its magnetic healer and its electric doctor is responsible for the delay in the use of electricity as a therapeutic agent by the honest practitioner. It is impossible to deny the fact that the charlatans and quacks do accomplish many wonderful cures by the use of this agent; and this fact is leading to a thorough investigation and examination in the field of electro-therapeutics. Many investigators did good work in this line, but it remained for Drs. Beard and Rockwell, of New York City, to compile in a scientific volume the results of their careful experiments; and properly they may be called the fathers of electro-therapeutics.

In the use of electricity by the laity, symptoms only were treated, without any reference to the disease; and it failed more often than it succeeded because it was not properly indicated.

We have undertaken to give you the essential laws governing electricity; the various forms of current and their peculiarities; and a brief outline of its physiological effects.

Electro-therapeutics is the study of electricity in its relation to diseased conditions, and for convenience we will divide it into two departments:

1st. Medical electro-therapeutics.

2d. Surgical electro-therapeutics.

Electricity is a stimulant, a tonic, and a sedative. A stimulant is anything that causes functional activity to go beyond the normal. To illustrate; a man takes a large drink of whisky and it stimulates the action of the heart so that instead of beating seventy-two beats a minute there are ninety to one hundred and twenty. The whisky is a stimulant because it causes functional activity to go beyond the normal.

A tonic is anything that will cause functional activity to tend toward the normal. You have a patient with a rapid, soft pulse, beating at the rate of a hundred and twenty a minute. You give your patient a dose of whisky, and instead of the pulse increasing, it diminishes ten, twenty or even thirty beats. In this case the whisky is not a stimulant but a tonic, causing the functional activity to approach the normal. To another patient with a pulse of sixty you give a dose of whisky and the frequency of the pulse is increased to seventy or seventy-two beats a minute. In this case the whisky is also a tonic, causing functional activity to tend toward the normal.

A sedative is anything that will quiet nerve excitement. It will cause functional activity to go beyond the normal under certain circumstances; it will cause functional activity to approach the normal under certain circumstances. It will quiet nervous excitement and nervous irritability under certain conditions.

At present all demonstrations of nerve action seem to be variations in the wave or molecular motion over the nerve; the result of force. Nerve action is one demonstrated form of wave or molecular motion; electricity is another; and the motion of electricity seems to be more nearly allied to the nerve motion than any other; some claiming they are identical. We will not enter into a discussion of the theory of the identity of molecular motion of electricity and nerve force, for there is too much of practical importance for us to learn, to spend any time on theories.

In the human body there are variations in the normal wave motion over a nerve. These variations are symptoms, and these symptoms are the results of variations in the normal wave motion over the nerve; some actual change in some organ or some functional derangement.

Nerve vibrations may be too rapid, too slow, irregular, or they may be stopped. Anything that will change the nerve motion to and beyond the normal is a stimulant; while anything that will change it to normal is a tonic or may be a sedative. As electricity is very nearly allied if not identical to nerve action, it must be a stimulant and nerve tonic.

The stimulating effects of electricity are the first to show themselves; they last but a short time and are the least important. But remember, it is also a tonic; it causes functional activity to tend toward the normal. This fact is very little understood. Electricity is generally looked upon as a stimulant alone, and when its stimulating effect is obtained its use is discontinued, and the true benefits of the remedy—its tonic effect—is not obtained. This is the reason why so many physicians use electricity for a time and then discard it, claiming its effects are temporary, while the real trouble lies in the fact that they did not use it long enough and in a proper manner to obtain its tonic effects.

The best tonic effects of electricity are obtained by general faradization and central galvanism. The best tonic effect of any drug is obtained when the whole system is brought under its influence. You would not expect to obtain much tonic effect from a cold bath if only one arm or leg was bathed; nor would you expect to obtain a general tonic effect from exercise if the exercise was confined to one arm or leg. In other words, the best tonic effect of a cold bath, a sea bath, or exercise is obtained by making it general. So we obtain the best tonic effects from electricity by bringing the whole nervous system under its influence.

The immediate effects of general faradization and general galvanism are:

1st. A feeling of drowsiness or exhilaration.

2d. Temporary relief from pain.

3d. An increased warmth of the body.

Precisely the same effects are often obtained from a cold bath, a sea bath, a brisk walk or a dose of alcohol. But like all other tonics, electricity may be pushed too far and produce bad results, the difference being that the bad results of electricity may not come until two or three days after its use, while the bad effects of bathing or exercise will show themselves within a few hours. Within two or three days after the current has been used the patient may have a feeling of general malaise, yawning, stretching, be nervous, irritable and exhausted, with an irregular pulse. These symptoms may last for a number of days.

The permanent effects of electricity are the same as the permanent effects obtained from any other tonic. The first permanent effect that will show itself will be an improvement in sleep. If you are giving a patient electricity, and upon inquiry you find he is sleeping better, you may know you are beginning to get the permanent effects of the agent. This improvement in sleep may precede any other favorable sign by a number of days and even weeks. Next there will be an improvement in the appetite, digestion and assimilation, and in the regularity of the action of the bowels. The next thing to show itself is an improvement in the circulation; at first the increase in the circulation lasts only a short time, but after awhile it becomes permanent, and the hands and feet that were formerly cold remain warm. Like all other tonics and tonic exercise, digestion improves under it; absorption is increased and the circulation equalized, consequently there is increase of nutrition. This increase of nutrition brings an increase in the size and weight, and the muscles become hard and firm.

The chief end of all tonics is to increase the capacity for mental as well as physical work; and in order to have increased capacity for mental and physical work there must be improvement in sleep, digestion, absorption, assimilation, and in the throwing off of the waste products of the body. All this electricity will do when properly indicated and properly given.

But remember that the good effects of general faradization

and central galvanism come slowly and may even come after the treatment has been discontinued.

Let me call your attention to this point: people who do not stand tonics well do not take kindly to electricity.

I am well aware that the subject of nerve action and its results, nutrition and the performance of function, is an exceedingly complicated one. Nevertheless we do know something about them, and if you will make yourself familiar with the few fundamental facts and principles to which I have called your attention, you will be much better able to understand why electricity is indicated in the treatment of so many different affections.

In this place I wish to give you a few general suggestions in regard to the use of electricity as a therapeutic agent.

As it is necessary for you to understand the physics of electricity in order to use it intelligently, so it is also necessary for you to learn the general laws governing its action in order that you may derive from it the proper results. I wish particularly to emphasize this point, viz: that you are not to use it in any disease because it has been recommended by some writer for the treatment of that disease; but you are to use it in any condition where a stimulant, a sedative, or a tonic is required. In other words, you are to treat each individual case, treating the condition of the system without any reference to the disease.

Whenever a case presents itself and it seems to you that electricity is indicated in the treatment of that case, put the following questions to yourself and answer them:

1st. Is there pain to be relieved?

2d. Is there need of and a chance for improvement in general or local nutrition?

3d. Are there any reasons why it should not be used?

If the first or second question, or both of them, can be answered in the affirmative, and the third in the negative, you may use electricity; and the results you obtain will depend upon:

1st. The skill with which you use it.

2d. The length of time.

3d. The curability of the disease.

Let me call your attention to a point here: in the treatment of disease by electricity a correct diagnosis is of very great importance.

A man comes to you with a partial paralysis of the face, arms and legs; you promise him that by the use of electricity he shall be cured; but had you studied the case carefully, obtained a complete history of it and made an accurate diagnosis you would have found it to be one of general paresis, and a condition where electricity would do no good.

As to the stage of the disease, the best results have been obtained by using the current in the sub-acute or chronic conditions. However, there can be no doubt that electricity is applicable in the treatment of acute diseased conditions. It will certainly be of service in the treatment of sprains, acute, articular and muscular rheumatism, and especially in the treatment of insomnia accompanying acute conditions.

A great deal has been written about the action of the two poles, and the direction of the faradic current. The facts are that the same results are obtained at both poles, and by either an upward or a downward current, there being only a difference in degree. With the galvanic current there is often a marked difference in the therapeutic effect; depending upon the direction of the current. I will give you some special directions as to poles and direction of current as we take up special conditions, and you will understand that they are the results of my experience.

You will obtain the stimulating, tonic and sedative effects from both the faradic and galvanic currents, and from both poles; but there will be a difference in degree. As a rule, when you wish to obtain the sedative effects of electricity you will use the galvanic current; using the positive pole over the irritated points, especially in the treatment of nervous diseases. When it is the stimulating effect that is wanted, as in the treatment of paralyzed muscles, you will use the faradic current.

A great deal of discussion has taken place as to whether you are to treat the disease per se, or whether you will treat the symptoms of the disease. If you treat the disease it will be scientific; if you treat the symptoms, understanding the disease, it will

be practical; but be both scientific and practical, treating the disease as well as the symptoms.

Electricity is not simply a stimulant to stir up paralyzed muscles; it possesses tonic and sedative properties and is not alone a tonic or a sedative, but by restoring normal nerve action, improves nutrition and circulation. As to the dose of electricity: to-day no office battery is considered complete without a milliampere-meter, and I think no one should attempt to use the galvanic current in the treatment of diseased conditions without a milliampere-meter in the circuit. As yet we have no way of measuring the faradic current. The dose of electricity will depend upon the strength of the current and the length of time applied, there being no definite law.

In considering special diseases I will give the dosage according to my experience. But note this rule: when strong currents are well borne they do good; when strong currents are not well borne, mild currents will do good. A great deal will depend upon the patient and the disease you are treating. At first use mild currents and use them only a short time. By far the best results are obtained by the use of mild currents in the majority of cases, and I think it is the experience of every physician who uses electricity intelligently, that each year finds him using milder currents in the treatment of the majority of cases. It is far better to use too little than too much. Many a good surgeon has had the results of a brilliant operation turn out disastrously by neglecting the details; and many physicians, using electricity intelligently, have not been satisfied with the results, and this is often due to the neglect of little things.

Let me call your attention to four points:

1st. Avoid sudden interruptions. If you are using a galvanic current and wish to increase or decrease the strength of the current slip the point of the switch from one button to the other very carefully, so as to avoid a shock.

2d. Be careful in the use of your electrodes. See that your conducting cords are firmly fastened to the binding posts and to the electrodes, so that a cord will not slip out of an electrode and drop on the patient; and never under any circumstances lay an

electrode or anything else that is metal upon your switchboard, for in this way it is very easy to short-circuit your battery.

3d. Use absolutely clean or aseptic electrodes.

4th. Be sure that your battery is working. Test the faradic current by holding the electrodes in your hand; test the galvanic current by bringing the ends of the cords together; or you may test it with your needle so as to be sure that your circuit is complete.

As to the disrobing of the patient preparatory for treatment, you must use your own ingenuity, but if you wish to treat the spine, do not attempt to slip the electrode under the clothing. If the patient is a woman have her bring a loose jacket that will open behind, so that you may have free access to the entire length of the spine. Of course, under these circumstances, you will have the temperature of the room such that the patient will not be chilled by disrobing, and you will see that your electrodes are warm; not only the covering wet with warm water, but that the electrode itself is warm.

As to the length of time for each application, it will depend upon the patient and the disease. The more irritable the patient the shorter the time; but the average time will be from twenty to thirty minutes and from once a week to every day. You will obtain the best results from mild currents used for a considerable length of time.

The greater number of cases you will treat with electricity are those on which drugs have been tried and failed. Often too much is expected and promised from the use of this agent in a short time. Remember that the good results of electricity are due to the fact that it restores normal nerve action, thereby increasing nutrition; and that such results require time. Of course you may relieve pain by a single application, but in the greater number of cases you should be careful to explain that time will be required: weeks, months, sometimes years. In many cases it is advisable to suspend the treatment for a few days or even weeks.

There are a few points you must remember, viz: how to judge the good effects of electricity; which will be:

1st. Relief from pain and disagreeable sensations.

2d. An improvement in the circulation, which will manifest itself by a more normal pulse and increased warmth of the body.

3d. An improvement in sleep and a quiet state generally.

4th. An increase in the capacity for mental work.

5th. Improvement in appetite, digestion and elimination.

6th. Improvement in local and general nutrition.

The bad effects of electricity will be:

1st. Sleeplessness accompanied by irritability, nervousness and even nervous chills.

2d. Headache and backache.

3d. Pain or increase of pain.

4th. Stiffness and dull aching of the muscles.

Let me emphasize this point: always, unless it is simply a local application to a leg, an arm or the face, have your patients rest after giving them electricity.

Many physicians when they have a case which in their judgment demands electricity will obtain for the patient or have them get for themselves a battery for personal use, telling them that they can treat themselves just as well as a physician can. This, however, is a grave mistake. You might as well turn a patient loose in a drug store and tell him to take anything he thought would be good for him. If your patient is too poor to pay you for your time, either treat him for nothing or send him where he can obtain free treatment.

If it is necessary for professional men to spend hours studying the physics of electricity and still more time in learning how to apply it, how can you expect a person who knows nothing of the agent to obtain from it good results. Under no circumstances whatever advise or allow your patient to obtain his own battery.

CHAPTER XVI.

Electricity in Disturbances of the Circulation.

The vaso-motor nerves control almost the entire circulation of the body. If we have circulatory disturbances we can control most of them through the action of electricity upon the vaso-motor nerves by its tonic or stimulating effects. The vaso-motor nerves are under the control of the great sympathetic nerve and we may act upon the vaso-motor nerves by acting upon the sympathetic.

For general circulatory disturbances let me give you this rule: to increase the circulation apply the positive electrode over the abdominal sympathetic ganglia, and the negative electrode over the terminal points. To decrease the circulation place the negative electrode over the abdominal sympathetic ganglia and the positive electrode over the terminal points.

To illustrate: here is a patient with poor circulation; cold hands and feet and a pale skin. We wish to increase the circulation. If we use the faradic current it will make little difference which electrode we place over the abdomen; but if we use a galvanic current we will place the positive electrode over the abdomen and apply the negative over the distant parts. If we wish to reduce the circulation we would simply reverse the direction of the current.

The faradic current may be used to increase the circulation in the muscular tissue.

You know that whenever a function is being performed an extra amount of blood is automatically supplied to the part performing the function. I move my arm, thereby performing a function. The movement of the arm is not the result of increased

circulation, but the performance of that function brings about an increased amount of blood in those muscles. In other words, the performance of a natural function increases the circulation in the part performing the function, thereby preserving its normal amount of nutrition and maintaining its normal size. Do not forget this point, for it will not only be of service to you, but enable you to understand the use of the faradic current in paralysis.

There are several ways of applying electricity to the human body.

First, let me speak of what is known as local electrolyzation, or the application of electricity to a given part. The object of this is to confine the current to some particular part of the body. The manner in which it is done is this: here is an arm which you wish to bring under the influence of the current in order that you may increase its nutrition, and you do not wish to affect the rest of the body. If it is a faradic current, put one electrode in the hand and touch the other over the different motor nerve points. If it is a galvanic current one electrode will be placed above and the other beneath, on the arm. Remember that you must keep the electrode moving when you are using the galvanic current.

Note particularly, that the strength of the current being the same, the smaller the electrode the more pain it will cause. This increase in the pain as the size of the electrode is diminished would suggest to you to use a large electrode with strong currents.

General faradization is another way of applying electricity to the body, and the object of it is to bring every part of the body under the influence of the current.

Placing one pole at the feet or over the coccyx, apply the other over the head and over the spine (increasing the current as you go down the spine), over the arms, legs, and possibly over the abdomen. The results of general faradization will depend upon the strength of the current, the thoroughness of the application and the frequency of the treatment.

Let me say a word here in reference to the use of the hand. You wish to give a patient general faradization. Placing an

electrode at the feet or at the coccyx and starting the battery, you take the other electrode in one of your hands, but hold it very lightly. Moistening the other hand in warm water you place it gently over the patient's forehead; closing the hand on the electrode you complete the circuit. By using your hand you know exactly the strength of the current, and the hand is much more agreeable to the patient than the sponge, and unless you are very susceptible to the action of the current it will do you no harm. After you have treated the head a few moments put your hand to the back of the neck. Then taking the other electrode pass it down the spine and over the other parts of the body.

In general faradization the general rule holds good that the best results will be obtained from mild currents used a longer time. Apply the current from five to thirty minutes, and from one to three times a week.

Let me give you in this place, one rule: the positive pole is much less irritating than the negative pole. In general faradization put the negative pole at the feet, or the coccyx; in central galvanism put the negative pole over the stomach. This leaves the positive pole (which is less irritating) to be used over the more sensitive parts.

A great deal has been written about the action of the two poles and the direction of the faradic current when the facts are that the same results are obtained at both poles and by both an upward and downward current, there being only a difference in degree. But with the galvanic current there is often a marked difference in their therapeutic effect depending upon the direction of the current.

Another method of applying electricity is what is known as central galvanism. The object of central galvanism is to bring the whole nervous system, which includes the brain, spinal cord, pneumogastric and sympathetic nerves, under the effect of the galvanic current.

One pole (usually the negative) is placed over the stomach or coccyx; the other pole is placed on the forehead; from the forehead pass the electrode back in front of the ear and down along over the external carotid artery, then around to the base of the

brain, and back over the same parts; then bring the electrode around on the other side, covering the same parts. Then beginning at the base of the brain, pass the electrode down the spinal column, increasing the current as you go down.

In the use of the galvanic current about the head, be sure that your current is not too strong, and when your patient returns for another treatment, inquire if he has any headache or if he has been dizzy. If he has, then your current was too strong.

CHAPTER XVII.

The Treatment of Paralysis by Electricity.

For many years the only practical use made of electricity was in the treatment of paralysis. Sometimes brilliant results were obtained from its use, and at other times no results. The reason of this was that the cases in which electricity was indicated in the manner in which it was used gave good results; while in other cases either electricity was not indicated, or else it was not properly used. The treatment of paralysis by electricity is a very important subject, and we will spend considerable time in its consideration.

Paralysis is only a symptom and it means loss of function. In order to understand abnormal conditions, we must understand normal conditions, or functions. Now note this: voluntary motion is the result of a motor impulse originated in the motor cells of the brain, carried over the nerve fiber to the muscle and producing contraction. If, then, there is a diseased condition in the center originating the motor impulses, or if that center is destroyed, or its function temporarily destroyed by pressure, as from a blood clot, inflammatory exudations, growths, or depressed bone, we will have paralysis of voluntary motion. Not because the muscle is diseased, nor because the nerve fiber is diseased; but because no motor impulse is originated that can produce muscular contraction. Remember that nerve impulses are molecular motion over a nerve fiber.

If the nerve center is in a perfectly healthy condition, but the nerve fiber connecting the center with the muscle is cut, or its

function temporarily interfered with by pressure, there will be paralysis of voluntary motion.

If the center is intact and the nerve fiber is also intact, but the muscle is diseased, we will have paralysis of voluntary motion.

Reflex action in voluntary muscles depends upon:

1st. The sensory nerves which convey the irritation to the multipolar cells in the anterior horn of the spinal cord.

2d. Upon the multipolar cells which receive and perceive the irritation and originate a motor impulse.

3d. Upon a motor nerve which conveys this motor impulse from the multipolar cells in the anterior horn to the muscle.

If there is a diseased condition of the sensory nerve, so that the irritation does not reach the multipolar cell in the anterior horn, there will be loss of reflex action in the voluntary muscles supplied by that nerve. If there is disease in the multipolar cell of the anterior horn, so that it cannot perceive the irritation, or originate a motor impulse, there will be loss of reflex action in the voluntary muscles supplied by the nerves from this part; and in addition to loss of reflex action there will be almost complete loss of voluntary motion; and there will be atrophy of muscles. If there is a diseased condition of the motor nerve connecting the anterior horn with the muscle there will be loss of reflex action, complete paralysis of voluntary motion and atrophy of muscles supplied by this nerve.

Sensation depends upon:

1st. A peripheral nerve that may be irritated.

2d. A sensory nerve to conduct this irritation.

3d. A center to perceive it.

If there is disease of the peripheral nerves so that they cannot transmit the irritation to the nerve fibers there will be loss of sensation.

If the sensory nerve fibers are cut, or the function of the nerve temporarily interfered with by pressure, there will be loss of sensation, because the irritation to the peripheral nerve fibers must be transmitted to the center and the center perceive the irritation before what we call sensation occurs. If, from whatever cause, disease or pressure, the sensory center in the brain is

destroyed or its function temporarily interfered with, there will be paralysis of sensation. If you fix these facts clearly in your mind, the treatment of paralysis by electricity will be a science. It necessitates, however, your making a correct diagnosis of the cause of the paralysis.

The objects of the use of electricity in the treatment of paralysis are two, viz.:

1st. To prevent atrophy of muscle and nerve, and preserve functional activity.

2d. As a curative agent.

Remember that electricity will not prevent paralysis, but will prevent the paralyzed muscles from losing their power of action when the normal nerve stimulant is restored.

To illustrate: Here is a patient who has had a cerebral hemorrhage or apoplexy, the right arm and leg being paralyzed. Over the motor area of the cortex of the brain there is a clot of blood. We know if nature performs her duty properly, aided or unaided, that in time that clot will be absorbed, and as a result the paralysis will disappear, providing the length of time intervening between the formation and its disappearance is not too long. If it is too long, there will be atrophy of the paralyzed muscles, caused by their being unused, so that motor impulses sent to these muscles from the relieved center meet with no response. Electricity is used upon these muscles to prevent this atrophy, and to keep them in a healthy condition; so that when the center is relieved of its pressure, and a motor impulse is sent from the center to the muscles, they respond. The second use of electricity in the treatment of paralysis is a curative action; curative by clearing up impaired centers and conducting paths in the nervous system that are preventing action.

Remember this general rule: the faradic current is to be used on the paralyzed muscles without any attention being paid to the direction of the current; but the current must be strong enough to produce moderate contraction of the paralyzed muscle. When you are unable to produce contraction of the paralyzed muscles with the faradic current, you must use the galvanic current; but you are to pay attention to the direction of the current, and to run

the current in the direction that you obtain contraction with the mildest current.

Let me explain: Here is a paralyzed arm upon which the faradic current fails to produce contraction; try the interrupted galvanic current and you will find that running the current downward, that is, placing the positive pole above and the negative pole below, it requires twelve cells to produce contraction. Reversing the current, you find that contractions can be produced with eight cells. In treating this case you will use an upward interrupted galvanic current. Every time, after applying the current, try the faradic current on these muscles, and as soon as the faradic current will produce contraction, cease to use the galvanic current.

In addition to the local use of electricity, connect the centers for the muscles with the muscles, passing the current in the direction of nerve force; this will compel vibrations along the natural way to the muscles, so that as soon as the center liberates a motor impulse the nerve is in condition to conduct it.

Let us endeavor to put some of these facts into practical demonstration, and make a clinical study of the application of electricity to the different forms of paralysis.

You desire to know when and how to use electricity and when not to use it, and why.

The first case, the history of which I will give you, is that of a little girl; the left leg from the hip to the knee is about the same size as the right, while from the knee down it is very much smaller. The muscles are soft and flabby; the limb feels cold and the foot turns in when she attempts to stand on it. This is a case of paralysis accompanied by atrophy of muscles. Is electricity indicated in the treatment of it?

The history of the case is this: the child is nine years old; when about five years of age she went to bed one night apparently as well as ever but awoke in the morning with the entire left leg paralyzed. There was no pain, no loss of sensation, no involvement of the bladder or rectum, and with the exception of the paralyzed leg the child was as well as ever. Within a few days she began to use the leg some, and within a few weeks the use of the leg from the hip to the knee was apparently as good

as ever. But the muscles below the knee began to waste and it was many months before she could stand upon the leg at all. There has been some slight improvement, and by the aid of a brace she is enabled to walk around.

From the history and our previous knowledge, we know that the trouble lies either in the motor center in the brain, in the fibres connecting the centers with the muscles, or in the muscles. If it were in the center in the brain the paralysis would not involve the entire limb at first and disappear in part of the limb, and there would be no atrophy except that produced by non-use. If the lesion were in the nerve fibers the same would be true. The lesion was not in the muscles, because the muscles did not begin to atrophy for several weeks.

We have paralysis of an entire leg which disappears in part of the leg, leaving that part apparently well. This would indicate pressure that was relieved. We have motor paralysis followed by atrophy of muscle. We know that the trophic centers for the muscles are in the multipolar cells of the anterior horns of the spinal cord; that congestion or inflammation in the spinal cord may cause pressure on the multipolar cells, temporarily interfering with the functions of some and destroying others; and would account for this condition. The child had an acute inflammation of the multipolar cells about the lumbar enlargement of the spinal cord, on the left side.

At first the products of the inflammation, such as the hyperemia and inflammatory exudation, were such as to press upon the cells which supply the entire leg. But as time went on the pressure was relieved on the cells that supply the leg from the hip to the knee by the absorption of the exudation and the lessening of the hyperemia, leaving some of the products of inflammation present and some of the cells completely destroyed, and the others partially destroyed. This is a case of poliomyelitis, anterior acuta; or (as it is improperly called) infantile paralysis.

Is electricity applicable in the treatment of this case, and how?

Two principal things must be accomplished in order to assure

a cure: the nutrition and motor irritability must be maintained and increased if possible.

The first thing to consider is what can be done with the muscles. Remember that wherever function is being performed there is excess of arterial blood, which means growth. If you can cause those muscles that are atrophied to perform artificial function you can increase their growth. How can it be done? By applying the faradic current locally to the muscles, and strong enough to cause muscular contraction. If that fails to produce contraction use the interrupted galvanic current, running the current in the direction that will cause contraction with the mildest current.

Hold one electrode at the bottom of the foot and turn on a mild faradic current of one cell with the helix shield pushed clear in, place the other electrode over the muscles, endeavor to touch the motor nerve points. You may not obtain contraction at first, and it may be necessary to draw the helix shield more than half way out before the muscles contract. Do not rub the electrode over the muscles but lift it and place it from point to point over the motor nerve points, every time producing contraction. This should be continued from five to ten minutes, two or three times a week. Every day the muscles should be rubbed with a coarse towel, and a suitable brace applied so as to keep the foot straight.

Remembering about the pathology of the disease you should endeavor to produce absorption of whatever inflammatory exudation there may be left in the spinal cord. This can be done—not with the faradic current—but with the galvanic current; and experience has taught us that the downward galvanic current will do it most effectually.

Place the positive electrode at the upper part of the dorsal region of the spine, and the negative electrode over the coccyx, using eight to fifteen cells. Keep your electrodes moving, running the current five minutes at a time. It will require months to make a perceptible change upon this case, but it can be done. The amount of improvement that will occur depends upon the number of cells destroyed in the anterior horns, and how much of

the function of the destroyed cells will be assumed by the remaining cells, together with the thoroughness and persistency of the treatment.

In order that you may learn to differentiate these cases of paralysis, and understand their treatment by electricity, let us compare another case with the one just cited.

A little boy has no use of his left leg; he cannot stand on it nor use it; and it is slightly smaller than the right, but not much. The muscles are not so firm as those of the right leg, but they are not nearly so soft and flabby as were the muscles in the case of the little girl.

If you blindfold his eyes and tickle the bottom of his foot there will be a reflex action, the foot being drawn up. This being a paralyzed leg, is electricity applicable in the treatment of it, and if so, how?

This is the history: the little fellow is seven years of age; until he was five and a half years old he was perfectly healthy; at this time he was taken with a high fever and vomiting and had a number of convulsions; was very sick for several weeks. When he recovered, the left leg was paralyzed. What is the condition of things? From the history, you will remember that there is but little atrophy of the muscles in the paralyzed leg, and what there is is due to non-usage. You also remember that by tickling the bottom of the foot there was reflex action in the paralyzed leg.

You know that reflex action depends:

1st. Upon a sensory nerve to convey the irritation to the multipolar cells of the anterior horn of the spinal cord.

2d. A healthy multipolar cell.

3d. A motor nerve to conduct the impulse to the muscle.

Reflex action is normal; therefore you have no disease of muscle, sensory nerve, multipolar cell of the cord, or of the anterior or motor nerve.

Where, then, is the trouble? There are only two other places where it can be.

1st. The center in the brain.

2d. The nerve fibers connecting the centers of the brain with the multipolar cells in the anterior horns of the cord.

The history of the case points to an inflammatory condition, but not to a hemorrhage, nor an embolus; because in hemorrhage and embolism if there is fever it follows the paralysis, and does not precede it. But here we have the paralysis following the inflammation. In other words, the child had an inflammation of the brain, or cerebritis. The spot that has been left diseased is along the right side of the superior longitudinal sinus of the parietal lobe, which is the center for the leg.

Is electricity indicated in the treatment of this case? Not as a curative agent. It may be invaluable, however, in preserving the motor irritability of the paralyzed muscles, and in the prevention of muscle degeneration; so that if by any means the cerebral center is restored to function the muscles can respond. This is a case where you may use a faradic current over the muscles and connect the center in the brain with the muscle, using a downward galvanic current.

It is the treatment of such cases as this by electricity, and failure being the result, that has caused many to doubt the efficacy of electricity in the treatment of paralysis.

But if you remember that paralysis is but a symptom, and study each case in the light of modern physiology and pathology, you will soon learn when to use electricity and when not, in the treatment of paralysis.

The following case is that of a man with a paralyzed arm, but without atrophy of muscles. The hand and arm are colder than normal and somewhat puffed; and there is no motion of the part except some slight movement in the fingers.

The history of the case is as follows: the man is a cooper by trade; he is forty-five years old; has always been well, but has been quite a heavy drinker. Three weeks ago, while at work, he noticed that he could not use the left arm and hand as well as usual, and in the course of an hour was compelled to quit work and go home. By the time he reached home the arm and hand were completely paralyzed as to motion, but sensation remained normal.

The rupture of a small capillary, a branch of the middle meningeal artery over the center for the arm of the right parietal lobe, slowly forming a clot in this locality, would give us this form of paralysis. We know that if nature perform her function the clot will be absorbed in time, and function will be restored. But while that clot is being absorbed atrophy of the paralyzed muscles and possibly of some of the nerve fibers from the centers to the muscles may occur; for you will remember that the trophic centers for the nerve fibers carrying motor impulses from the brain are the cells in the cortex of the brain.

The indications, then, for treatment are:

To prevent atrophy of paralyzed muscles and preserve their functional activity. This we can do by the use of the faradic current over the muscles strong enough to produce moderate contractions.

Place one electrode in the hand and with the other touch the motor nerve points of the muscles on the back and front of the fore-arm, arm and shoulder, and on the back of the hand, producing contractions of each group of muscles and compelling function to be performed. Notice this particularly; it is where many fail in the treatment of these cases. Do not rub the electrode over the muscles but move it from place to place, locating the points that, when touched, will produce contraction.

A little later on, after the man has regained some slight motion in the parts, you will have him put one electrode in the hand and while he makes an effort to flex the arm you will place the other electrode over the biceps. Flex the arm and while he makes an effort to extend it place the electrode over the triceps. With one electrode in the paralyzed hand, it being pronated, and while he makes an effort to supinate the hand the other electrode should be placed just below the elbow, over the supinator muscles. With the hand supinated, while he makes an effort to pronate it, place the other electrode just below the elbow, over the pronator muscles. With one electrode over the flexor muscles at the radial and carpal articulations, and while he makes an effort to flex the fingers, place the other electrode over the flexor muscles just below the elbow. With one electrode in the same locality on the

back of the arm, and while he makes an effort to extend the hand and fingers, place the other electrode over the extensor muscles just below the elbow. In this way every set of muscles are exercised and encouraged to perform their natural functions; thereby preventing atrophy and preserving the functional activity of the muscles.

In addition to this, you may place the positive galvanic electrode over the center for the arm on the right cortex, using from six to ten cells; the negative electrode being placed over the paralyzed muscles. In this way you can assist in the absorption of the clot and preserve the functional activity of the nerve fibers. This, however, is a dangerous method and one that you must use with great care. Perhaps a better way would be to place the positive electrode over the base of the brain and the other one over the muscle.

The following history is that of a man who went to sleep one night, and when he awoke in the morning found that he had twisted his arm under him and lain upon it, and it was helpless. This is a case where the paralysis is due to the bruising of a nerve, and where you should use the faradic current over these muscles in the same manner as was advised previously. In addition use the downward galvanic current over the course of the nerve, using eighteen to twenty cells for about five minutes, but be sure to keep the electrodes moving. This class of cases will require close attention for some time, but under the action of electricity they will recover. Many do not recover spontaneously, but some do.

The following is the history of a man who is forty-six years old. He has never had any sickness or injury, except a hard chancre, which he had twelve or fifteen years ago. The present trouble began a little over three years ago; he noticed that he could not get around as well at night; that he had difficulty in going upstairs; that he had trouble with his eyes—double vision; then he began to suffer with what he called rheumatism; there were sharp pains in the legs. The difficulty of walking at night increased, and he found that he could not walk as well as usual in the daytime. The pains increased; they were of a sharp shooting

character, and he began to have trouble with the bladder and bowels, but without rise of temperature.

Upon examination it was found that he was not able to walk at all with his eyes closed, nor could he stand with his heels together if his eyes were shut. It was almost impossible for him to put his foot upon a chair, he having to make several attempts in order to do so. Blindfolding him and testing for the tendon reflexes, it was found that the knee jerk was entirely absent in both legs. Testing for the superficial reflexes, they were found to be almost entirely absent. Testing for sensation, it was found that a pin could be thrust into the foot or leg anywhere below the knee without his knowing it.

There was no atrophy of muscle, and the man was able to use his legs and walk, after a fashion, with the use of a cane, if it was light and he had his eyes open. The absence of knee jerk means loss of muscle tone; the absence of the superficial reflexes, with the anesthesia and analgesia (loss of painful sensation) means that there is trouble either in the sensory nerves between the peripheral and cord in the reflex arc, in the sensory column in the cord, or trouble in the brain.

There is no loss of sensation in the hands or arms, nor in any part of the body above the knee; therefore the trouble does not lie in the brain. There is no atrophy of muscle; therefore the trouble is not in the anterior horns of the cord. Then it must be in the sensory nerves. But where? Between the cord and the skin, or in the cord? If it were between the cord and the skin, there would be some trophic conditions of the skin present. Therefore it must be in the cord.

We know that the posterior columns of the spinal cord carry to the cerebrum impressions that result in sensation. If the columns are diseased, the brain does not receive or appreciate sensations. But this man has difficulty with his walking. Is it paralysis?

It is not motor, but is sensory paralysis. That is to say, the difficulty in walking is due to the fact that the muscle sense (which is a sort of telegraphic communication between each muscle and the cerebrum, which takes place over the posterior

sensory columns) is cut off, and the brain does not know, except through the eye, the position of the muscles; hence the difficulty in walking. In other words, this is a case of locomotor ataxia. Is electricity indicated in the treatment of it? I think not. Some temporary relief from pain may be obtained by a downward current over the cord.

The following case is of a laborer thirty-three years old, who has been a hard drinker for a number of years. When he came under my care he gave this history: Eight weeks before he had been taken with what was called rheumatism, and was sent to the hospital. He had a great deal of pain in his legs and arms, accompanied with much numbness and a tingling, pricking sensation. He could not use his feet; at least he thought he could not. He had no special trouble with his bladder or bowels, and did not have much fever. After remaining in the hospital for four weeks he was able to be up, and, with the aid of two canes, to get around a very little. When he first came to me it was almost impossible for him to walk with the aid of his cane; he staggered like a drunken man; but with his cane could walk almost as well with his eyes shut as with them open.

Upon examination we found no atrophy of muscles. The tendon reflexes were lost, the superficial reflexes very much diminished, and sensation was slow but not lost. Here is a condition of things very similar to the last case, yet this man is getting well, while the other man is steadily growing worse.

Let us see wherein they differ. The first case was chronic, the symptoms gradually coming on; this case is acute, in which the symptoms are gradually passing away. The first case had eye symptoms, with bladder and bowel trouble and no fever, while this case had no eye symptoms nor any special bladder or bowel trouble, no fever. This is a case of multiple neuritis from chronic alcoholism. There is congestion, with more or less inflammation of the nerve fibers or their sheaths. You must reduce it and produce absorption of whatever products of inflammation there may be between the nerve and its sheath.

A downward galvanic current over the spine (using ten to fifteen milliamperes), the positive electrode over the spine, pass

the negative electrode over the course of the sciatic nerve and its branches, and over the course of the anterior crural nerve. Never use the faradic current in the treatment of these cases of multiple neuritis until galvanism has been given a thorough trial, and never use it early.

CHAPTER XVIII.

Treatment of Paralysis—Continued.

Let me give you the history of a few more cases of paralysis that differ somewhat from those already cited.

The first is a man thirty-five years old. Four years ago he noticed that he could not go upstairs as well as usual, that it was difficult for him to lift his feet, and he was apt to stumble. In the morning when he awoke his legs were very stiff, and it required several hours to get them limbered up. By degrees this condition increased, until he can only walk by the aid of two canes, and by sliding his feet along. He has never had any trouble with the bladder or bowels, he has had no pain. He can walk just as well with his eyes closed as with them open.

Upon examination we found that the tendon reflexes were very much increased; so much so, that striking the tendon of the quadriceps of one leg we not only obtained a very pronounced knee jerk of that leg, but also a knee jerk of the other leg—a radiated tendon reflex. As you know, increased tendon reflex means increased muscle tone; which means nerve irritation.

Testing for sensation with a pin point, we found that sensation was normal over both feet and legs. The superficial reflexes, though diminished, were not lost; they were diminished on account of the increased muscle tone.

What is the state of affairs? There is no muscular atrophy, consequently no involvement of the anterior horns of the cord or the anterior nerve roots. Neither is there involvement of sensation. Where, then, is the trouble? It must be either in the spinal cord or the brain.

If it is in the spinal cord, it involves only the motor fibers of the cord. If it is in the brain, it must be located between the two

hemispheres along the superior longitudinal sinus. The only condition that could possibly exist here would be pressure, and that would give paralysis of motion in the legs, but it would not give increased tone of muscle; and it would be very much quicker in coming on than has been the case in this instance.

The trouble, therefore, must be in the motor fibers of the cord or the crossed pyramidal tracts. Of what nature is this? It cannot be a hemorrhage for it has been too long developing. It may be a tumor, but it is not probable. The symptoms have gradually increased in severity, showing a gradual interference with the functions of these fibers.

The probabilities are that from some cause there has been developed a hyperemia of the spinal cord, which has resulted in the formation of new tissue between the fibers of the motor tracts; and that this new tissue has gradually pressed upon and cut off the conductivity of these motor fibers. Is electricity indicated in the treatment of this case? Theoretically, yes; practically, no.

This is a case of paralysis, but you would not think of using a faradic current over those muscles, for it would do no good. Whatever good electricity may do in the treatment of this condition will be by a downward galvanic current over the cord; but I would not promise anything in the treatment of such a case.

The following is the history of a case that presents apparently a worse condition than that of the man just cited.

The young lady is not able to walk except by the aid of two crutches. She must swing herself along, and is barely able to stand upon her feet long enough to lift the crutches or put them down. She is nineteen years old, and has been in this condition for three years. She was sitting at the supper table one evening apparently as well as ever. Suddenly she said "I feel faint." Her father helped her from the table to a bed in an adjoining room where she lay down; and in a few minutes the faint feeling passed away. When she attempted to sit up she found both her legs were helpless. There was no pain in them, nor has she had pain at any time, and she has had no trouble with either bladder or bowels.

Upon examination it was found that there was no involvement

of sensation; that the superficial reflexes were somewhat increased, and the tendon reflexes were lost in both legs. The muscles were somewhat soft, but not atrophied to any extent. She cannot straighten out the legs, nor lift the feet from the floor; in fact, is not able to use them at all.

Let us see what is the condition of things. Superficial reflexes somewhat increased and no atrophy of muscle. You know that the superficial reflexes depend upon the sensory nerve to conduct the irritation to the spinal cord, a center in the spinal cord; the multipolar cell to receive, perceive and originate a motor impulse; and a motor nerve to conduct that impulse to the muscle.

In this case the superficial reflexes are somewhat increased. That would indicate a normal sensory nerve, a normal motor nerve, and a normal spinal center. The tendon reflexes are lost, which indicates low muscle tone. Where, then, is the trouble? As in the last case, it must be either in the spinal cord or in the brain. If in the brain it must be in the superior longitudinal sinus. Such a condition is exceedingly rare in young people, is rarely present without some head symptoms, and rarely, if ever, causes complete paralysis.

The trouble must be in the motor tract of the cord. Coming on suddenly with paralysis as a result would indicate pressure. Sudden pressure upon the motor tracts of the spinal cord is almost invariably hemorrhage within the spinal canal, so as to press upon the pyramidal tracts on both sides. Is electricity indicated in the treatment of this condition? Yes.

1st. To preserve functional activity of the muscles. This you will do by the application of a faradic current direct to the muscles, having the current strong enough to produce moderate contractions.

2d. Use a downward galvanic current of from fifteen to twenty-five cells over the spine, to increase or assist in absorption of the clot.

This case will doubtless improve very rapidly. Passive motion should be made, and she should use every effort to move the limbs.

The next history is that of a woman who is sixty-five years

old. She was in the hospital for several weeks suffering with an attack of pneumonia. When she recovered her husband took her home in an open buggy, a ride of several miles, with a cold wind blowing upon her. The next morning when she awoke she found that her mouth was very much drawn to the left side; that the right side of the face had dropped, and she could not use the muscles, nor could she close the upper or lower lid of the right eye.

Looking into the mouth, we found that the uvula and palate were in a normal condition. By drying the tongue with a towel, and testing first one side and then the other, we found that taste was normal.

This is a case of Bell's paralysis, or paralysis of the facial nerve.

Is electricity indicated in the treatment of this case, and how?

Taking one electrode in the hand and having the other electrode held at the back of the neck, wet the other hand in warm water and turn on a faradic current strong enough so that when you touch the paralyzed muscles with your fingers they will contract. Go carefully over these muscles, making each one act. With one electrode at the back of the neck and the other electrode over the muscles (endeavoring to get as near the nerve ends as possible), compel the muscles to act. In the same manner, she making an effort to close the eyelid at the time the electrode is applied to the nerve, you will observe the eye close. Having her open her mouth while the electrode is applied over the nerve ending, she makes an effort to close it at the time the current is completed. This case should be treated in this manner two or three times a week, and it will recover in a few weeks under the use of the current.

A man who is fifty-eight years old presents practically the same conditition of things, with a few exceptions. The face was drawn to the left side instead of the right, as were the uvula and palate. Drying the tongue with a towel, and testing it by placing salt upon it, he told me that taste on the right side of the tongue was normal, while on the left side he tasted nothing. This

is also a case of Bell's paralysis, but it differs in its cause and prognosis.

In the first case the paralysis was due to cold—a local action upon the nerves after they leave the bony canal. In the second case the paralysis came on just as suddenly. The man went to bed well and arose with his face paralyzed; but the uvula and tongue being involved indicates that the trouble lies within the skull, and in such a locality as to involve the nerves supplying the palate, uvula and tongue. There was probably a minute hemorrhage within the stylo mastoid foramen or canal.

The treatment of the two cases will be practically the same; the first case will get well in a few weeks, while the other will require months, and may never recover.

From these cases you will observe that in nearly fifty per cent. of the cases electricity has not been indicated in their treatment. If you attempt to treat a case of paralysis by electricity, be sure you understand the nature of that paralysis. Do not attempt to treat a condition in which electricity is not indicated by it. Study each case by itself, and if electricity is indicated in the treatment of that case, and you use it properly and thoroughly, it will not disappoint you.

CHAPTER XIX.

Treatment of Neuritis by Electricity.

The following history is that of a man who complained of having trouble with the first finger of his right hand, and, to some extent, with the arm. He is a cabman forty-five years old. Has a good family history. Has never been very sick, and is temperate in his habits. Four months ago, while closing the door of his cab, the first finger of his right hand was caught between the door and the jamb. It was not bruised, and he paid little attention to it. But the pain gradually increased; the finger became somewhat stiffened, and by degrees the pain has involved the greater part of the hand, and at times the forearm and arm. The last two joints of the finger are stiff, the skin over the finger is glossy in appearance, and the nail brittle.

This case is one of a class that is quite common. It is usually called rheumatism or neuralgia, and treated accordingly. It is neuritis or inflammation of the nerve.

You will remember that I gave you a history of a case of multiple neuritis in the chapter on the treatment of paralysis by electricity.

Simple neuritis, of which this is an example, may be acute or chronic, or, more properly speaking, acute or subacute. In acute neuritis it is the axis cylinder or the conducting part of the nerve fiber that is affected, while in the subacute and chronic forms it is the sheath of the nerve that is affected.

This case is one of the subacute form. The pain and tenderness and the glossy skin are due to the fact that the inflammation of the sheath of the nerve and the products of the inflammation—hyperemia and exudation—are pressing upon the nerve fibers

and destroying their conductivity, at the same time being a source of constant irritation.

You know that the galvanic current is sedative at its positive pole and stimulating at its negative pole. In this case use a galvanic current locally to the arm, placing the negative pole above and the other below the elbow, keeping it moving; and the positive pole moving over the finger, back and palm of the hand, up along the radial nerve and its branches, and along the ulnar nerve and its branches, using from twenty to thirty cells, or from twenty-five to fifty milliamperes from five to ten minutes. This will soon cause absorption of the exudation between the nerve fiber and its sheath, and cause the hyperemia to disappear.

In this way the pain will be relieved and the appearance of the skin will become normal. But, as you observe, the last two joints of the finger are stiff, and there is some atrophy of muscle.

After the pain has been relieved by the application of the galvanic current, the faradic current may be used over the muscles of the finger, and passive motion of the last two joints must be made.

It will require a great deal of patience on your part, and a great deal of persistency on the part of the patient, but these cases do not recover of their own volition. This inflammation will extend until other branches of the radial nerve are involved, and ultimately the nerves of the entire arm may become involved. However, galvanism, if persisted in, will cure these cases.

Here is a somewhat similar condition in a book-keeper, thirty-five years old, who is temperate in his habits. In his childhood he suffered with St. Vitus's dance, or chorea. He has an epileptic sister, and his grandmother died insane. Several weeks before he came to me he began to have considerable pain in the ring and middle fingers of the right hand. This pain gradually increased so that while at work, and for several hours after, it involved the entire hand and forearm. He has never had any cramps in the muscles or in the hand. This is a form of writer's cramp—one of the neuroses of which we know little. We know that it requires proper soil, in the shape of a susceptible nervous system such as the history of this man presents, and although he

does not have cramps or muscular spasms, it is practically a typical case.

Galvanism applied in the same manner as was advised in the last case of neuritis, and about the same strength, will soon relieve the pain.

But something more than this must be done for this case. He must learn to write with his pen-holder thrust between his fingers or passed through a medium-sized cork, and change the manner of his writing. He says that he writes mostly with the finger and forearm movements. He must learn to write with the whole arm movement, and do his adding with his left hand. Of course it would be much better if he should quit work entirely.

The same condition, with or without local spasms, as you are aware, may result from any occupation requiring constant and fine co-ordination of the muscles governing the hand and fingers. If you are wise, you will not promise too much or too speedy results from any line of treatment.

Sciatica or sciatic rheumatism, or neuralgia as it is often called, is quite a common condition, and one which you will be frequently called upon to treat. Often the cause of the sciatica is rectal or pelvic trouble. In treating sciatica with electricity, use a large electrode over the lumbar region, with the negative pole of your galvanic current attached to it, and the positive pole over the tract of the nerve, using from ten to twenty-five cells, or from fifteen to fifty milliamperes. But do not forget that if the cause of the sciatica is rectal or pelvic trouble, the application of galvanism will not cure, but simply give temporary relief.

CHAPTER XX.

Neuralgia—Digestive Disorders.

In this chapter I wish to give you a few general ideas in regard to the use of electricity in several conditions.

Let me call your attention to the use of electricity in the treatment of neuralgia. Do not misunderstand me. I appreciate the fact that neuralgia is a pain referred to a nerve, that it may be caused by many things, and that the treatment of the pain in the nerve by the application of electricity may not be very scientific, but it will often be exceedingly practical. For a neuralgic pain that has resisted all other forms of treatment may yield, at least temporarily, to the application of electricity.

A good general rule for the application of electricity is, whenever pressure aggravates the pain of neuralgia, use the positive galvanic current over the sensitive point; and when pressure gives relief or does not aggravate the pain, use the faradic current. Try either pole on the sensitive spot, beginning with a very mild current, gradually increasing the strength, and you will probably at first have aggravation of pain. If this does not subside very soon, change the poles. If the faradic current is indicated, you will almost always have aggravation of pain at the beginning of the treatment, which gradually subsides. The current should be stopped as soon as there is marked accession of pain.

It makes no difference whether the neuralgia is in the head, arms, shoulders, chest, legs, or where it is, this general rule will hold good, and often some of the most brilliant results you will ever have will be obtained by treating neuralgia with electricity.

Electricity has been advised in the treatment of many digestive disorders, but there are only two conditions of the digestive

tract that I have treated specially with electricity. I have obtained good results in these conditions, and I doubt not that the current will be of service in the treatment of other conditions.

Flatulence can often be quickly relieved after all other measures have failed by the application of a mild faradic current to the abdomen, using a large electrode over the back. Perhaps the best results will be obtained by faradic massage. That is to say, one electrode is placed over the patient's back and the other is taken in one hand of the operator, while with the other hand he kneads the abdomen. Where the flatulence is due to a lack of tone, the best results will be obtained.

The other condition to which I wish to call your attention is constipation. A constipated condition of the bowels may be dependent upon many things. Perhaps the most common causes are:

1st. Diseases of the rectum.

2d. Inactivity of the bowels—the reaction from drugs.

It is a notorious fact that more medicine is taken and given to regulate the movement of the bowels than for all other complaints to which the human race is subjected, and there is no other part of the human anatomy so prone to become inactive. The reaction from these drugs leaves many suffering with chronic constipation.

Electricity is indicated in the treatment of these cases, and will give you most satisfactory results, providing there is no rectal or pelvic trouble. Many cases of chronic constipation which are due directly to rectal trouble will still remain after the rectal trouble has been removed. This is due to the inactivity of the bowels, and in these cases also electricity is indicated.

The manner of application should receive special attention. By far the best results will be obtained by using a large-sized rectal electrode, and attaching to it one pole of the faradic current, and using the hand over the abdomen; first beginning over the small intestine, then gradually working around to the right iliac fossa, thence over the tract of the colon, over its ascending, transverse and descending portions. After the current has been used in this manner for five minutes or so, connect both poles of the battery to the rectal electrode, and use as strong a current as

can be borne. This treatment should be repeated two or three times a week, and in bad cases every day.

At first, if the bowels will not act, they must be compelled to move by large enemata containing glycerin. However, as soon as the habit is established the enemata should be discontinued.

As a matter of fact, beneficial results will be obtained from the treatment of general debility and neurasthenia by general faradization and central galvanism on the digestive organs and intestines.

Electricity has been used quite extensively in the treatment of chronic congestion of the liver and in the so-called torpidity of the liver.

In chronic congestion a faradic current of fair strength is applied directly over the liver. One electrode is placed on the back over the region of the liver, while the other electrode is moved over the region of the front of the liver.

The current is increased gradually and continued for from five to thirty minutes. The treatment is given for from one to three times a week. In the so-called torpidity of the liver a mild faradic current is used in the same manner and often gives excellent results.

CHAPTER XXI.

Hysteria—Spinal Irritation—Neurasthenia—Insomnia.

I wish to call your attention to four conditions very closely allied.

1st. Hysteria.

To the physician who has worked hard and patiently for months to improve the condition of a hysterical patient, and finds that on the slightest provocation all his work is for naught, any measure that will help him in the treatment of his case will be gladly welcomed.

Electricity has been and will be one of the most potent agencies in the treatment of hysteria known to the profession.

2d. The so-called "spinal irritation."

I doubt very much the existence of a true spinal irritation, but were I classifying nervous diseases I should probably place those cases that are now designated spinal irritation with hysterical cases.

However, there can be no doubt that there are cases where there is an increase of arterial blood in the spinal cord and its membranes. In many of these cases this irritation is due to rectal, ovarian, digestive or sexual disturbances, and the relief to the spinal condition means the removal of the source of the irritation. Electricity will do these cases good, but it will not cure them until the source of the irritation is removed.

3d. Neurasthenia or nervous prostration.

There is perhaps no class of cases that come under the care of the physician that are as trying and exhausting as these cases of neurasthenia, and it requires all the tact, skill and patience that a physician can summon to his command to restore them to

health. These cases are very closely allied to hysteria and the so-called spinal irritation.

4th. Insomnia.

The insomnia in which electricity is indicated (if you will allow the expression) is purely nervous, where the patient is simply unable to get the nervous system sufficiently quieted to sleep. The treatment of these conditions by electricity has been recognized for some time, and ever since Dr. Weir Mitchell adopted his treatment of rest, electricity and food, much has been expected of and a great deal has been obtained from electricity in their treatment.

Before outlining in detail the treatment for these conditions, let me give you a few practical points:

1st. In cases of hysteria, spinal irritation or neurasthenia, if possible have your patient procure a sufficiently substantial electrical outfit to give them good treatment at home.

2d. Always, if it is in the range of possibilities, give these patients their treatment at night. Have them in their own bed, and do not allow them to get out of it after a treatment, and insist upon as much rest in bed as possible.

3d. Remember the general rule—that mild currents long continued give better results than stronger currents for a shorter time. This is especially true of this class of cases.

Galvanism is to be used over the spine first. The negative pole is to be attached to a large abdominal electrode, and the positive pole used over the spine and over the neck, along the tract of the carotid arteries. Use a current of ten to fifteen cells from twenty to forty minutes.

After this has been given, the faradic current is to be used, still using the large abdominal plate; taking the other electrode in the hand, and, with the other hand well moistened, begin at the back of the neck with the kneading process; with the hand go down the spine from top to bottom on either side of the spinal processes, using a mild faradic current. After this has been used from fifteen to thirty minutes, take a towel and thoroughly dry the skin over the spine and your hand. Now, you will remember that when the skin is dry the current does not penetrate to the deeper

parts. Still leaving on your large abdominal electrode, and taking the other electrode in one hand, pull out the helix shield, begin at the back of the neck and go down the skin, using the knuckles of the hand and barely touching the skin. In this way you can obtain the tonic effects that would be obtained from static sparks. For spinal irritation and hysteria this treatment as outlined will be best. For nervous insomnia the galvanic current will be all that is necessary, and often this same treatment will bring a quiet sleep to patients suffering from acute diseases, after other measures have failed. For the cases of nervous prostration, in addition to this give them electrical massage over the arms and legs.

If you rely entirely upon electricity in the treatment of these conditions, or if in the treatment of any other condition you use electricity and exclude all other lines of treatment, you will make a great mistake. But especially is this true in the treatment of the conditions named.

Study each case of hysteria, spinal irritation and neurasthenia by itself, and find, if possible, the source of the irritation. If you fail to obtain from electricity the desired results in the treatment of these conditions, study the case farther, as there is almost certainly some undiscovered source of irritation or nerve waste.

CHAPTER XXII.

Rheumatism.

Rheumatism was one of the first conditions treated with electricity, and to this day there are many physicians who think that practically all the good there is in electricity as a therapeutical agent is in the treatment of paralysis and rheumatism.

In the treatment of acute inflammatory rheumatism I have had no experience. Some cases of chronic articular rheumatism are very greatly benefited by the application of the galvanic current. A mild current must be used, the positive electrode over the joints and the negative electrode over the epigastrium, coccyx, or at the feet. Occasionally in these cases a mild faradic current will do good. Do not put the electrode over the joints, but use your hand. For the treatment of muscular rheumatism use a mild faradic current applied over the affected muscle, and at the same sitting give the patient general faradization. For that troublesome affection called lumbago, electricity is of very great service. Usually the galvanic current will give the best results. Use the negative pole over the abdomen with a large electrode, and the positive pole to the affected muscles. Generally a current of from fifteen to twenty cells is required in the treatment.

Some of these cases are exceedingly troublesome, and galvanism alone may not give the desired results. If it does not, after giving the galvanism, thoroughly dry the back and your hand, and using a strong faradic current, pass your knuckles over the affected muscles. Of course you will not forget the internal administration of proper remedies. For ordinary, every-day backache (which, by the way, is not nearly as often spinal congestion as might be supposed, and is quite frequently spinal

anemia), a downward galvanic current of from eight to fifteen cells will nearly always give relief. But do not expect galvanism to cure a backache due to a displaced uterus, reflex conditions from the rectum, or sexual excesses, unless the cause is removed.

It is in that form of rheumatism that is generally called muscular, but should be called neuralgic, that electricity will give the most satisfactory results. For the pains in the shoulders, arms, knees and legs, a galvanic current (the negative pole over the spine, the positive pole over the tract of the nerve, using a medium current) will generally give you the desired result. But do not give your patient one electrode in one hand and the other electrode in the other hand, switching on your current, and expect it is going to cure them; yet this is the way many physicians treat patients by galvanism, and wonder why they have such poor success.

Sprains.

Galvanism will give you nice results in the treatment of acute sprains, particularly where there is considerable swelling and a great deal of pain. The positive electrode is applied over the sprained member, and the negative over the abdomen, coccyx, or at the feet, using a mild current.

Chorea or St. Vitus's Dance.

There is quite a common disease which is treated almost universally with electricity, and often improperly so, and that is chorea or St. Vitus's dance. The best results in the treatment of chorea will be obtained by central galvanism, not using a strong current. This should be followed by faradic massage over the spine, the directions for which have been already given.

Incontinence of Urine.

Incontinence of urine will often yield to a mild faradic current, using a sound in the bladder and one electrode over the coccyx or perineum. But before you treat such a case, look your patient over carefully and ascertain, if possible, what is the cause of the incontinence. If the cause is rectal or intestinal disturb-

ances, or local irritation of the bladder or urethra, electricity will do no good until the cause has been removed. But if the incontinence is only a symptom of a general nervous condition, general faradization and perhaps central galvanism will materially assist you in the treatment of your case.

Diseases of the Male Generative Organs.

Of late years electricity has been used quite extensively in the treatment of the male generative organs; the whole train of symptoms that follow masturbation, from the slight atrophy of the parts with occasional seminal emissions to almost complete atrophy of the testes, the nightly emissions, sometimes two or three of them, and true spermatorrhea.

I am well aware that in giving you the following directions I am going contrary to the teachings and writings of many of the best neurologists of the day. They claim that it is the mental condition which brings about the general constitutional depression that accompanies these cases, and that it is the mind that must be treated, demonstrating to the patient the fact that his physical condition is not altogether due to the habit. At the same time, I know it is very much easier to convince a patient that he will soon recover his health and strength if you are able to partly control the emissions, and cause a return of healthy condition to the parts.

In treating these cases, pass the largest urethral sound that can be passed without too much pain. Connect one electrode to the end of this sound, and pass the other electrode over the lumbar and lower dorsal regions of the back, over the perineum and testes, not using a very strong faradic current, and repeating it two to three times a week.

If the case is one of true spermatorrhea, after treating with the faradic current as just given, change your current to the galvanic, using the positive pole connected with the sound in the urethra, and the negative electrode over the lumbar and lower, dorsal region, using from six to ten cells from two to three minutes. Keep the sound in the urethra moving. In these cases, if there is very much atrophy of the parts, use the positive

electrode over the back and the negative electrode directly applied to the parts, using from fifteen to thirty cells ten to twenty minutes. You will be surprised to see how quickly the parts will return to their normal size.

For the treatment of impotency, use the same method with the faradic current, but use one electrode more particularly over the perineum, and directly over the parts.

Now let me call your attention to this fact: many of these cases are due to direct irritation from the rectum, particularly to rectal fissure; and if you attempt to treat them by electricity without first removing the cause, you will fail.

For a number of years much discussion has taken place as to the efficacy of galvanism in the treatment of urethral stricture, many writers claiming that it will cause it to disappear, as the dew before the rising sun, while others claim it has no effect whatever. They are both right and wrong. Many cases can be rapidly cured, others cannot be.

I shall give you briefly my method of treating these cases. Locate as accurately as possible the stricture or strictures. Pass through them the largest urethral dilator that will pass (for this work I prefer the olive-tipped bougie); take the next largest in size to the one which has passed through the stricture or strictures, and insulating all except the tip with a small-sized rubber tubing, connect it with the positive pole of your galvanic battery as shown in Figure 125.

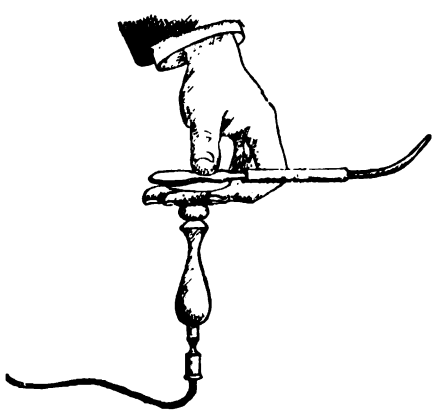

FIG. 125.

Place the negative electrode over the back; now pass the bougie into the urethra until it strikes the first stricture. Switch on from two to four cells, quickly pass the olive-tipped sound through the stricture or strictures, and as soon as the point passes beyond the stricture break the circuit; for if

you should leave your positive electrode in contact with the mucous membrane of the urethra for two or three minutes you would have an eschar. In this way dilate the stricture or strictures to whatever size you may wish.

Remember that the positive electrode will not produce absorption of urethral strictures, but it will produce dilatation. You must be quick, however, in handling it and use a mild current.

As soon as you have dilated the stricture or strictures until you can pass in a steel sound, do so, and connect it with the negative electrode, leaving the positive to be applied to the back or over the perineum.

Wishing to produce absorption, you must use from six to fifteen cells ten to twenty minutes.

CHAPTER XXIII.

Diseases of the Female Pelvic Organs.

Some one has said that "Woman is a uterus, around which is located a set of organs—that when the uterus is normal the set of organs act harmoniously; when it is abnormal, they do not act properly. Woman will laugh when the uterus is healthy and cry when it is diseased."

Be this statement true or not, it is a deplorable fact that with the advancement of civilization diseases of the female pelvic organs have become more prevalent. The only way to account for this is, that woman has drifted away from the ideal. The unnatural method of dress, the exposures at improper times, the excesses, have all tended to increase pelvic diseases in women; and the physician who to-day does not understand uterine and ovarian reflexes, and appreciate the importance of a healthy condition of these organs, is not doing all that can be done for his patient in the light of modern investigation.

To-day the ideal treatment of pelvic diseases of women is surgical interference. The physician who cannot count his operations upon the uterus by the score, and his laparotomies by the dozen, is not looked upon as a very high authority in this department. So popular has this procedure become, that many cases of slight irritation and congestion of the ovaries are operated upon; the ovaries removed, the result is premature old age, and often only temporary relief from pain. I do not wish to deride or belittle in any way the achievements of modern antiseptic abdominal surgery. Brilliant results have been obtained and wonderful cures wrought by the skillful operator, but abdominal surgery has reached its present degree of perfection at the cost

of many lives, while hundreds of women have become prematurely old and their usefulness interfered with in a great measure, in order that some ambitious operator might perform a laparotomy.

The great number of text-books that have been written within the past few years on gynecology, and their remarkable sale, manifests the interest that the profession at large are taking in the treatment of diseases of women. To the beginner, or practitioner to whom this field of work is new, the great difference in treatment of the various pelvic diseases is quite bewildering; and he is ready to welcome anything that will be of service in the treatment of these conditions.

If electricity has made for itself any reputation or gained any laurels in the treatment of paralysis, nervous diseases and so on, it also has made a reputation in the treatment of the diseases of women that surpasses any other treatment yet devised; and to-day we stand on the threshold of the treatment of these diseases by electricity; and no one can say to what extent it may yet be developed. In taking up the application of electricity to the diseases of women, we will not attempt to go to any length in the consideration of the etiology, but will simply touch upon a few of the conditions in which electricity may be indicated.

The first that would be thought of in the treatment of pelvic diseases of women is pain, which may be due to:

1st. Abnormal condition of the uterus.

2d. Abnormal conditions of the ovaries and tubes.

3d. Abnormal condition of the pelvis, independent of the uterus and ovaries.

Pain in the uterus, except when due to a malignant condition, is nearly always due to:

1st. Active or arterial congestion, or inflammation.

2d. Passive or veinous congestion.

The causes of active arterial uterine congestion, such as cold, traumatism, or septic infection, you are familiar with.

In our present state of knowledge, it is doubtful whether electricity is applicable in the treatment of acute congestion of the uterus. If the congestion has not gone on to inflammation it is possible that a mild faradic current with a vaginal electrode, and

the other electrode over the uterus, may do good. But with our present knowledge I do not feel like advising the use of electricity in this condition. Perhaps within a few months, or years at most, this problem will be solved.

Of the passive congestion of the uterus, there are many causes. One of the most common is the laceration of the cervix. Do not attempt to treat chronic congestion of the uterus with electricity when it depends upon a lacerated cervix, and expect from it permanent results; but after the laceration has been repaired and the uterus still remains congested, you can use electricity and expect to obtain good results.

Another very common cause of chronic congestion of the uterus is that condition known as subinvolution. To treat subinvolution of the uterus with electricity, you should begin the treatment with a mild faradic current, using a vaginal electrode, while the other electrode is placed over the uterus and region of the ligaments; using the current from ten to fifteen minutes. After the treatment, lift the uterus well up into position with a glycerin tampon. Repeat this twice a week for two or three weeks.

Now use the intra-uterine and the large abdominal electrodes with a mild faradic current, allowing the current to pass for ten to fifteen minutes. Afterwards lift the uterus well up with a glycerin tampon. Of course, at the same time you may make any other application to the interior of the uterus, the cervical canal, or the external os, you may see fit. You will be agreeably surprised to note how rapidly these chronic conditions will subside under this treatment.

Another cause of passive congestion of the uterus (very frequently overlooked) is improper sexual intercourse. Some of the most difficult cases you will have to deal with will be due to this cause. If you can remove the cause and use a mild faradic current in the manner indicated for the treatment of subinvolution, you can soon cure those cases. But if you do not remove the cause, do not blame electricity if it fails to give the results required.

Another very common cause of passive congestion of the uterus is disease of the rectum resulting in chronic constipation. The

treatment of this condition has already been given. Let me call your attention to this fact: the treatment of the uterus without the treatment of the existing constipation will give only temporary relief. Of the part that uterine displacements play in the causation of chronic congestion of the uterus and their treatment, I will have nothing to say now.

The abnormal condition of the ovaries and tubes producing pain, in which electricity will be applicable in the treatment of, are:

1st. Congestion of the ovaries and tubes.

2d. Ovarian neuralgia, as it is called.

It is truly wonderful how the intense pain in the ovaries and along the tubes can be relieved by a mild application of the faradic current, using a vaginal electrode and the other electrode over the seat of pain.

In the young girl you may use the large electrode over the back in place of the vaginal electrode. This same treatment will nearly always give relief for the neuralgic pain in the ovaries. If, however, it does not, you may use the galvanic current; using the negative electrode over the lower region of the back, and the positive electrode over the seat of pain.

Of the diseased conditions of the pelvis other than those spoken of, such as pelvic hematocele and pelvic cellulitis, I do not think that electricity is indicated in the acute stage. The treatment in the subacute and chronic stages will be considered in another chapter.

CHAPTER XXIV.

Menstrual Disorders.

We take up now for consideration the application of electricity in menstrual disorders.

Electricity is indicated in menstrual disorders:

1st. For the establishment of the menstrual period.

2d. In amenorrhea.

3d. In dismenorrhea.

4th. In metrorrhagia.

In the establishment of the menstrual period electricity will often be indicated, as it will be in the following class of cases, viz:

A young girl is fourteen, fifteen or sixteen years of age. The figure has rounded out and there are all the signs of maturity. For many months she has had a leucorrheal discharge lasting for a few days. Then the menstrual flow appears, but it is scanty, lasting but a short time. Then for a number of months she has leucorrhea with backache and headache, and often nosebleed.

The internal administration of remedies often aggravates these conditions. In these cases use a mild secondary faradic current; using a large electrode over the lumbar region of the back and the other electrode over the region of the ovaries and uterus, using the current ten to fifteen minutes once a week, and twice the week preceding the menstrual period. Two or three months of such treatment will finally establish the menstrual period, to the great relief of your patient and her friends. Let me insist that you use a mild current.

Amenorrhea is an absence of or a scanty, irregular menstrual flow. There are many causes for amenorrhea, among which we might mention:

1st. An absence or imperfect development of the pelvic organs.

2d. An impoverished condition of the blood.

3d. Certain diseases of the nervous system.

4th. Certain organic diseases.

Within the past few years electricity has been used quite extensively in the treatment of this condition, irrespective of cause. Often it has succeeded and often failed. The best results in the treatment of amenorrhea by electricity are obtained when the amenorrhea is due to lack of development in the pelvic organs. These are the cases that have reached the age of eighteen or twenty-one years, or even older, without menstruating or with a scanty, watery menstruation, months intervening between periods. These cases have taken any quantity of drugs and have been treated by innumerable physicians without results. It is wonderful what electricity properly used will do for these cases; "properly used," in these cases means a great deal. If you are to successfully treat them you must begin aright.

Make a thorough examination of the pelvic region. The ovaries you will not be able to find and the uterus is soft and flabby, being from three-fourths of an inch to an inch and a half in depth. With a large abdominal electrode and an intra-uterine electrode begin the treatment with a very mild faradic current from ten to fifteen minutes twice a week. After a few treatments still continue the faradic current; but after you have used it from five to ten minutes change to a galvanic current with the negative pole within the uterus. Use a current as strong as the patient will bear from five to ten minutes. Let me caution you to be sure your electrodes are thoroughly antiseptic.

After treating these cases thoroughly wipe out the uterine cavity with some antiseptic—as listerine or sanitas—and pack around the cervix some antiseptic gauze or absorbent cotton, to be left for twenty-four hours.

By carefully following out this treatment in the course of a few months you will find the uterus increasing in depth and menstruation will appear. It may require months of treatment, but

when you remember that these cases have tried all other forms of treatment, you will not be discouraged.

In that class of cases where amenorrhea is due to an impoverished condition of the blood—as anemia, chlorosis, phthisis, Bright's disease, etc., electricity is not indicated. It will do no good and it will do no harm; these are the cases that require constitutional treatment.

However, there is a class of cases where the amenorrhea is due to a lack of nerve force, and these cases are quite common. At the proper age these persons mature and menstruate regularly, but from sudden shock or severe cold the menstruation ceases or becomes irregular.

In these cases you will use the faradic current after the manner described for the establishment of the flow, or with a vaginal electrode in the place of the electrode over the back. In addition you may use general faradization or central galvanism.

In this connection there is another class of amenorrheas that, although not very common, are not infrequently met. A woman gives birth to a child, nurses it for several months and then weans it. Menstruation appears nine or ten months after the birth of the child. After the weaning the menstruation grows less and less and she begins to increase in weight, and as it diminishes she continues to grow heavier. After a while the menstrual flow lasts but a day or two and amounts to nothing. A large abdominal electrode and an intra-uterine electrode used with a mild faradic current ten to fifteen minutes at a time, once or twice a week, will soon bring about a normal flow. Where amenorrhea is due to organic disease electricity is not indicated.

Dismenorrhea is painful menstruation, and may be due to several causes. The most common causes are uterine displacements or flexion, stenosis or contraction of the cervical canal and arterial congestion of the uterus and ovaries. The treatment of displacements as the cause of dismenorrhea we will consider later.

For the treatment of stenosis electricity will be of great service. The method that I employ in the treatment of these

cases is perhaps somewhat different from that employed by many others, but it is the result of experience.

Take a large abdominal electrode and to it attach the negative pole of your galvanic current. If the cervical canal is very small, find your way through it with a copper sound. Then, if possible, pass into it the smallest of your graded uterine sounds; take the next in size of your graded uterine sounds and slip over it a piece of rubber tubing that is four or five inches long, so that should the sound come in contact with the speculum, it would be insulated from it. (Fig. 126.) Now carefully withdraw the sound that is within the cervical canal, and pass the one thus prepared (after it has been dipped into an antiseptic solution) as far as it will go. As soon as it meets with resistance, connect the end of the sound with the positive pole of your galvanic current. (Fig. 125.) Switch on four or five cells, and in a moment the sound will pass into the cervical canal. Switch off the current and break the circuit, allowing the sound to remain a minute. Withdraw it and pass the next larger insulated sound until it meets with resistance; connect it with the positive galvanic current and switch on your cells. It may require six to eight cells for this sound to pass into the canal, but in this way it will thoroughly dilate it.

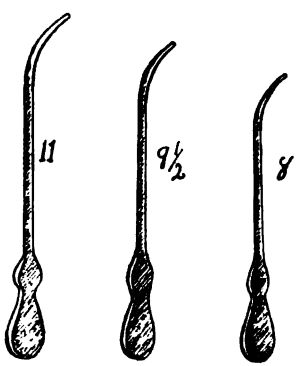

FIG. 126.

Now, let me caution you to keep the sound moving, for if you do not it will burn, and the last state of that patient will be worse than the first, for as it heals it will contract.

After you have done the above, wipe out the uterine cavity with an antiseptic solution; place in the cervical canal two or two and a-half inches of antiseptic drainage tubing, through the outer end of which has been slipped a shaker pin, leaving a string tied to the pin. Pack around the cervix some antiseptic gauze or some absorbent cotton. Have the patient leave the drainage tube in for twenty-four hours, and then remove it.

This treatment is generally all that is necessary for these cases. It is done with little or no pain, and the results are very satisfactory. Sometimes, however, after the stenosed condition has been relieved, pain will continue at the menstrual period. These are the cases where the pain is in the uterus, ovaries and tubes. A vaginal electrode and the other electrode over the region of the uterus, ovaries and tubes, with a mild faradic current, will soon relieve it.

There are two causes of metrorrhagia or excessive menstruation in which electricity is applicable in the treatment.

1st. Fungoid growths. By this I do not mean uterine fibroids, which will be considered at another time.

2d. Lack of uterine tone.

For the treatment of fungoid growths within the uterine cavity, the first thing to do is to thoroughly dilate the cervical canal in the manner described to you for the treatment of stenosis. Then use a stronger current, with the positive pole within the uterus, keeping the electrode moving and attempting to bring it in contact with all the parts of the uterine mucous membrane. This will require a current of twenty-five to fifty milliamperes. Wipe out the uterine cavity carefully with an antiseptic solution, and leave proper drainage.

When the metrorrhagia is due to a lack of uterine tone, such as often follows miscarriage and occasionally labor at full term, use the faradic current. Place one electrode over the uterus and the other within the uterus; use as strong a current as can possibly be borne.

Much more could be said on the treatment of menstrual disorders by electricity, but I have given you enough in outline to show you many cases in which it is applicable. However, let me impress this upon your minds. Do not use it in any condition unless you are sure that you know the cause of the condition and unless electricity is indicated in its treatment.

CHAPTER XXV.

Uterine Displacements.

To the general practitioner as well as to the specialist there is no class of troubles so unsatisfactory to treat, both to the physician and patient, as uterine displacements. Much time and ingenuity has been expended on mechanical contrivances to overcome them. Many eminent gynecologists have claimed and still claim that these mechanical supports are useless; while others equally as eminent are as loud in their praise.

It is not my intention now to laud or condemn mechanical supports for the displacement of the uterus, but rather to add what experience has taught of the usefulness of electricity in the treatment of these conditions.

Electricity is of service and often curative in the treatment of displacements of two kinds, viz.:

1st. The most common form, those displacements not complicated by any adhesions. The uterus is either retroverted, anteverted, or there is a lateral version, but it is movable.

The first essential in the treatment of uterine displacements is to relieve the passive congestion. If there is a laceration of the cervix it must be repaired. I do not mean that every laceration of the cervix requires stitching, but it must be healed.

The next essential in the treatment of uterine displacements—and it will also materially assist in the relief of the congestion, is a thorough dilation of the cervical canal. This you will do in the manner described in the treatment of stenosis. Dilate the cervical canal so that at least a No. 11 graded sound will pass into it; better if it is larger. After this is done pass into the uterine cavity the largest sound that will pass, having insulated the sound

from the speculum with a piece of rubber tubing; then take the large abdominal plate to which has been attached one pole of your faradic current, and connect the other pole to the sound within the uterus, using a mild current. After using the current for a few minutes, make a fulcrum of the thumb and finger of one hand, and with the sound rotate the uterus into its proper position. While you hold it there with the sound, again complete the circuit, using as strong a current as can be borne. Allow the current to pass from ten to fifteen minutes, then withdraw the sound and carefully wipe out the uterus with some antiseptic solution. Now comes an important part in the treatment. Make a vaginal tampon of antiseptic wool; wet it with glycerin. If it is a retroversion or a lateral displacement (which is by far the most common), pass that tampon in back of the cervix. Withdraw your speculum and have your patient rise to her feet and stand facing you, while you sit on a chair and raise your right foot upon the heel; then have the patient put her left foot upon the toe of your right foot; with your hand under the clothing, pass the finger into the vagina against the tampon, and having the patient lean well over your right shoulder, push the tampon as far as possible up behind the uterus. Have her allow this to remain for two days and then remove it. Forbid the use of hot douches, except what is necessary for cleanliness.

The reasons for this treatment are that the thorough dilatation of the cervical canal assists in removing the uterine congestion, and the use of the current strengthens the uterine supports as well as the vaginal walls. The wool tampon, while it depletes the uterus, placed in the manner described lifts the uterus into an almost normal position, lessens the strain upon the ligaments and gives them a chance to regain their tonicity. By and by, when the uterus is relieved of its congestion, the tampon may be made simply of the wool dusted with boracic acid, and allowed to remain several days. If the uterus is prolapsed but not flexed, and there is no laceration of the perineum, the same treatment will be applicable. In the course of a few months the uterus will stay in position without support, unless there is a chronic constipation complicating the case. Many of these cases have a chronic con-

stipated condition of the bowels, due to a diseased condition between the external and internal sphincters of the rectum—such as fissure, hemorrhoids, etc. These must be attended to.

For the second class of uterine displacements, those complicated with adhesions, not so much can be done. They are generally looked upon as incurable cases, yet many of them can be cured and many more made comfortable by the use of electricity as an adjunct in the treatment. If the uterus is retroverted or the displacement is lateral (and these are the cases with which you will have the most trouble), you must begin your treatment by the use of the galvanic current.

Over the end of your vaginal electrode put some absorbent cotton, and over the cotton slip a rubber band, so that should the current become strong, it will not produce ulceration of the vaginal mucous membrane. To your large abdominal plate connect the positive pole of the galvanic current, and to the vaginal electrode the negative pole, using as strong a current as can be borne without too much pain. Allow the current to pass from ten to fifteen minutes. After you have given a few treatments in this way, dilate the cervical canal in the manner described; then with your intra-uterine electrode connected to the negative pole of your galvanic current, use as strong a current as can be comfortably borne. After this treatment make an attempt to put the uterus in position with the sound; at first it will move but a little, but after a while it will be found to be more movable. Then you may alternate the galvanic and faradic treatment as already described. Use the tampon in the manner described in the treatment of other cases.

Always take pains to have your electrodes thoroughly aseptic and thoroughly wipe out the uterine cavity after the treatment. Many of these cases will not recover, but enough will to repay you for your trouble.

You must persist in the treatment, remembering that as a rule these cases are hopeless under other treatment.

CHAPTER XXVI.

Uterine Inflammation.

There are a few diseases of the female pelvic organs in the treatment of which electricity is applicable, that we have not considered.

We will first consider endometritis and endocervicitis.*

You will find in after years, if you have not already found, that chronic cervicitis or particularly chronic endometritis is one of the most difficult conditions to treat that will come under the care of the physician. It will tax your patience, ingenuity and skill, and anything that will be of service to you in the treatment of this condition will be welcome.

Of the various causes of endocervicitis and particularly of endometritis—for except in the pregnant uterus endocervicitis rarely exists alone—we will speak of but three, viz.:

1st. Laceration of the cervix, which of course you will not attempt to cure with electricity.

2d. Stenosis of the cervical canal. It makes no difference what treatment you follow for chronic endometritis, you will fail to cure the case unless the cervical canal is freely opened, the manner of dilating which you already know.

3d. Uterine displacements. You will not attempt to cure your case without making an effort at least to correct the displacement.

As to the method of using electricity for endometritis and endocervicitis, galvanism will give the best results; the negative electrode applied to the cervix and the cervical canal and with a large abdominal electrode, using a current of from ten to fifteen milliamperes.

*See chapter on Interstitial Electrolysis.

For the treatment of chronic endometritis I follow the treatment given as an accompaniment to the treatment of uterine fibroids by galvanism.

There are two chronic pelvic conditions in which electricity is applicable, and from which brilliant results have been obtained in otherwise practically incurable cases. I refer to pelvic hematocele and especially to chronic cellulitis with effusion and formation of pus. In these cases the large abdominal electrode and the vaginal electrode (be sure to cover the vaginal electrode with cotton), using the negative electrode in the vagina with a current of from ten to fifty milliamperes, will produce very rapid absorption of the exudation and may stop the formation of pus; in this way enabling you to relieve conditions which you could not otherwise reach.

For many years electricity has been looked upon as an important agent in the treatment of extra-uterine pregnancy. Much has been written regarding it and much discussion has taken place in regard to the efficacy of different currents; I think, however, that the best plan is to follow the one generally adopted now and use both currents.

After finding as accurately as possible the location of the tumor, begin by using the faradic current. Use a vaginal electrode or an intra-uterine electrode or one electrode over the back and the other over the abdomen; the object being to bring the current as near as possible to the tumor. Start the current mildly and increase it to the limit of the patient's endurance; then suddenly switch on two or three cells for a few seconds, then switch them off. Allow the current to pass as strong as can be borne, then without any warning suddenly increase it again for two or three seconds. Repeat this treatment two or three times a week for a few weeks, then you can begin to use the galvanic current. You may use a vaginal electrode and an abdominal electrode, or you may use an electrode over the back and an abdominal electrode. Start with a light current, preferably, with the negative electrode within the vagina or over the back; gradually increase your current until you have reached all your patient will bear, then suddenly with your pole-changer interrupt the current

several times very rapidly. After a few such treatments the growth of the tumor will cease and it will begin to decrease in size. Now you may use the negative intra-uterine electrode or the electrode over the back, using from fifteen to seventy-five milliamperes from five to ten minutes at a time, twice a week, to produce absorption of as much of the growth as possible.

Since antiseptic laparotomy has become so successful, electricity has not been used to such a great extent in the treatment of extra-uterine pregnancy. Even where laparotomy is contemplated the use of electricity to stop the growth is generally very beneficial. Incidentally in this connection, let me suggest the use of the faradic current to establish the flow of milk after confinement. With one electrode in the axilla and the other in one hand of the operator, with the other hand gently manipulate the breasts. By a few applications of this kind the flow of milk will become established.

I have not mentioned all the diseases of women in which electricity is applicable, but I hope that I have given you enough to enable you to understand the general scope of its usefulness and to eliminate those cases in which it must necessarily be useless.

CHAPTER XXVII.

The Treatment of Uterine Fibroids by Galvanism.

The treatment of uterine fibroids has been a question that has agitated the mind of the physician ever since the existence of such growths has been known. It is not necessary for me to enter into a description of the etiology, location, diagnosis and symptoms of uterine fibroids. Every text-book on gynecology devotes several chapters to the consideration of these growths. Until a few years ago the treatment has been by internal medication, hypodermics and the knife. It is scarcely necessary for me to say that hypodermics and internal medication alone, rarely, if ever, removed the growths. The knife, up to the time of modern antiseptic laparotomy, has been an exceedingly dangerous procedure, except in those few cases where the growth was situated in the cervical canal, or just within the internal os. Even with modern antiseptics, there are but few who care to remove uterine fibroids with the knife, for the mortality from such operations is great.

Ever since Apostoli wrote his first article on the treatment of uterine fibroids by galvanism, there has been a great deal of interest manifested by the profession, and much discussion taken place as to whether the treatment of these growths by galvanism was productive of good results or not.

Many eminent gynecologists have claimed that galvanism has no effect whatever upon uterine fibroids; while others equally renowned claim that the treatment will do all that Apostoli claims for it. It would be very unjust for me to say that some or all of these eminent gynecologists are wrong, still I think that too much has been claimed for the galvanic treatment of uterine fibroids, and at the same time I am prepared to prove that the treatment

is productive of good results. I have yet to see the first case of uterine fibroids properly treated, that was not benefited.

I have already said that a large majority of physicians using electricity in their practice know but little of its action and nothing of details of treatment except what they have acquired by experience. Every one who reads and is at all interested in the treatment of uterine fibroids must know that the galvanic treatment devised by Apostoli consists of applying the galvanic current to the uterine growth. Those who are successful with the treatment are those who thoroughly understand the laws of electrics and the details of the treatment and never neglect in a single case nor in a single treatment the care of these details.

Before we proceed with the detail treatment there are a few points to be laid down.

1st. You must have at least twenty-five cells in your battery.

2d. You must have either such a switch-board that your switch may slip from one to another button without breaking the circuit, or a rheostat.

3d. You must have a milliampere-meter.

4th. You must have proper electrodes.

Remember these facts.

So far as the treatment of uterine fibroids is concerned we may divide them into two classes, viz.:

1st. Those that are not accompanied by excessive hemorrhage.

2d. Those that are accompanied by excessive hemorrhage.

Remembering:

1st. That the negative galvanic pole is stimulating and will produce absorption.

2d. That the positive galvanic pole is hemostatic.

3d. That you are never to use anything but a platinum electrode within the uterine cavity or in the tissues when using a current of high amperage.*

4th. That the larger the electrode the stronger the current that can be borne without pain.

Now as to the details of the treatment. Every case of uterine

*See chapter on Interstitial Electrolysis.

fibroid that will come to you for treatment will present one of two conditions: either the size of the tumor and the resulting pressure is the thing complained of, or they come complaining of hemorrhage, and you may have these two things combined.

There is a little preparatory treatment necessary in every case if you are to obtain good results from galvanism.

1st. Carefully examine the patient and locate as near as possible the tumor or tumors.

2d. Examine carefully first the cervical canal, and second the lining of the uterus.

There are very few patients who have excessive menstruation. The increased vascularity of the uterus incident to the growth of the tumor causes the mucous membrane of the uterus to be in a state of congestion in the greater number of cases, and it must receive proper attention.

The best thing to do with these patients is to give them an anesthetic and rapidly and thoroughly dilate the cervical canal, and then curette with a blunt or sharp curette, as the case may demand, the uterine cavity.

After the curetting, the uterine cavity should be painted with the tincture of iodin and proper drainage should be left for twenty-four hours. If, however, the patient objects to the anesthetic, or if for any reason you should not deem it advisable to give an anesthetic and use a curette, other measures must be taken to accomplish practically the same results; also dilate the cervical canal in the manner described for stenosis.

If the directions are carefully followed, a thorough dilatation can be made with but little discomfort to the patient. After this has been accomplished, wipe out the uterine cavity carefully with absorbent cotton, removing, if possible, all mucus. Paint it thoroughly with equal parts of tincture of iodin, 95 per cent. carbolic acid and glycerin. Leave a drainage, which is best made of a small piece of antiseptic drainage tubing through one end of which has been slipped and fastened a small-sized shaker pin, leaving a string tied to the pin. Direct the patient to leave the drainage tube in for at least twelve hours. Have her return

in three or four days for another treatment, when the same procedure will be gone through with again.

If the cervical canal has contracted so as to interfere at all with a thorough medication of the uterine cavity, dilate it again. Treat the uterus in this manner twice a week until the mucous membrane is in good condition.

If the case is one accompanied by excessive hemorrhage, after three or four treatments you may begin to use your galvanism. But the best results are obtained by getting the mucous membrane of the uterus in good condition free from granulations, and relieved as much as possible of its congestion.

If, which occasionally happens, you should not be able to get at the cervical canal and the interior of the uterus, you may begin the use of your current with a vaginal electrode. But be sure and cover the end of the vaginal electrode with moistened absorbent cotton and slip over the cotton a rubber band to retain it in position. The reason for this is, that if you allow the electrode to come in contact with the uterus or the vaginal walls without being covered, while using a current of high voltage, you will have an ulcer which will be very difficult to heal.

As to the application of the galvanic current to the growths:

Remembering that you wish to use a strong current and that the larger the electrode the stronger the current can be borne without pain, you should select a large abdominal electrode. Apostoli used potter's clay, but very few American operators use it. The drum, or Martin's electrode as it is called, or the spongiopiline electrode are the ones most generally used. The Martin's electrode is very satisfactory; it is, however, very apt to leak. I prefer and generally use the spongiopiline; wet it in hot water; wet a thin cheese-cloth towel in warm water and spread it over the abdomen and place your electrode on it. Let me call your attention to this point: pass your hand all around the electrode and if the edge at a single point comes in contact with the skin, put under it the folded end of a dry towel. It will require considerable knack and quite a good deal of patience on your part to know just how to cover your electrode so as to prevent your patient's clothing from getting wet; but if you are careful

you can generally accomplish this. If, when your patient returns for treatment, you find a number of little blisters over the abdomen (and you should always look for them), be sure and cover each one either with a small piece of rubber plaster, or, what is still better, with a little rubber that has been dissolved by chloroform.

Most writers on this subject advise the use of the intra-uterine electrode without a speculum, but I prefer to use the speculum. Carefully wiping out the uterus with absorbent cotton wet with listerine, I take my platinum intra-uterine electrode and carefully disinfect it, either by passing it quickly through the fire or by putting it in a strong carbolized solution. This I pass into the uterine cavity, adjusting the rubber shield so that the electrode is insulated from the speculum, and complete the circuit by connecting the electrode with the cord of the battery. Before the circuit is completed, we take it for granted that you had tested your battery and found that it was in working order. Without an exception I always begin the treatment with the positive pole within the uterus. Switch on the cells carefully. Instruct your patient that under no circumstances is she to lift or move the abdominal electrode. If the current becomes unbearable, she must notify you so that you can decrease the strength of the current. For the first few treatments a current of from fifteen to twenty-five milliamperes is strong enough, using the positive pole within the uterus. Now let me emphasize this point: do not allow the intra-uterine electrode to remain in one position but keep it moving within the uterine cavity.

The treatment should be from five to fifteen minutes in length. Gradually decrease the current, remove the electrode and with some absorbent cotton and listerine carefully wipe out the uterine cavity and put a piece of drainage tube in the cervical canal, the same as you used after the dilatation. A very important point in the treatment is this: never, under any circumstances whatever, allow the patient to pass right out of your office without resting. Have her rest from twenty minutes to half an hour, and it will be better if she can lie down. The treatments are to be given two or three times a week. After four or five

treatments and the hemorrhage is controlled, you then wish to produce absorption of the growth.

In the place of the positive electrode within the uterus use the negative, taking the same careful antiseptic precautions; but you must increase your current to eighty or two hundred milliamperes. If you will always wipe out the uterus, put in your drainage tube and have your patient rest after the treatment, your patient will not be apt to have a troublesome colic following the treatment.

I am in the habit of always using the positive pole within the uterus the first treatment after the menstrual period.

So far I have said nothing of electro-puncture, or, in other words, of piercing the growths with a platinum needle and using the abdominal electrode. It has not found favor with me. Every case of uterine fibroid that will yield to galvanic treatment at all, will yield to it without electro-puncture. It is a dangerous procedure and one that I would not advise under any circumstances.

As to the results of the treatment: the first thing that will be apt to show itself will be marked improvement in the patient's general condition; also relief from pain and disagreeable sensations.

2d. If you carry out the careful internal treatment of the uterine cavity and use your electrode properly you can absolutely control the excessive hemorrhage.

3d. If you will take the pains to carefully measure your patient you will find that not in a single case will the treatment fail to stop the growth of the tumor, and I have yet to see a case of true uterine fibroid that will not be reduced in size by proper treatment. The amount of reduction will depend upon the thoroughness, the frequency and the persistency of the treatment.

Let me call your attention to this fact: after you have given the treatment two or three months and you find that the tumor instead of decreasing is increasing in size, it is not a true fibroid, but is a fibro-cystic tumor. Here is where the mistake is often made and where galvanism is condemned unjustly, for a growth of a cystic nature will be increased by the application of galvanism.

If you are going to treat uterine fibroids with galvanism, do it thoroughly and carefully. If you do, you may not have the satisfaction of seeing the growths entirely disappear, but you will have the satisfaction of seeing their growth arrested and more or less absorption occur, the hemorrhage controlled, your patient's health improve and she become free from pain and disagreeable sensations.

CHAPTER XXVIII.

Interstitial or Metallic Electrolysis.

Some three years ago Professor Gautier, of France, made a number of experiments with electricity based upon chemical facts. Knowing that the positive pole of the galvanic current gave an acid reaction, that its action upon the tissue resulted in the evolution of free oxygen, and that the tissue contained chlorin in combination with sodium in the form of common salt or sodium chlorid, he began experimenting with different metals to form a new salt.

Taking metallic copper, as a piece of copper wire, and passing it into a piece of meat, connecting it with the positive pole of the galvanic current and completing the circuit, he observed that with a current of from three to eight cells there appeared a ring of greenish tinge around the copper wire from one-eighth to one-quarter of an inch in width, in a few moments.

The action is as follows: The positive pole liberates free oxygen, which acts upon the copper and the oxid of copper is formed. This oxid of copper coming in contact with the chlorin of the tissue in the form of common salt, the oxychlorid of copper is formed, which new salt was in the nascent state and would penetrate the tissue to a considerable extent. This new salt was found to possess stimulating properties to sluggish granulations; to chronic inflammations of mucous membranes in general. It is an excellent germicide, acting especially upon the germs of gonorrhea.

Other metals were used in the same manner; zinc being connected with the positive pole gave the oxychlorid of zinc; iron giving the oxychlorid of iron.

This chemical fact was utilized in the treatment of certain diseases, especially those of the mucous membranes of the uterus, urethra, nose and throat. At the same time it was found that if a copper electrode was attached to the positive pole of the galvanic current and applied to old chronic ulcers of the leg, and the circuit completed by putting the negative pole close to the ulcer, that a faint greenish tinge was found present over the surface and proved to be an excellent stimulant to the granulations, causing them to fill in very rapidly where other measures had failed.

In the treatment of chronic inflammations of the nose and throat, especially those that have abnormal secretions, causing a constant hawking and clearing of the throat and blowing of the nose, the copper electrode often relieves in a few treatments.

Metallic electrolysis, for so this method of treatment is called, has proven of great benefit in gynecological work, especially in chronic endocervicitis and chronic endometritis. Let me give you directions for the treatment of chronic endometritis, and let that suffice for this method of applying metallic electrolysis. Simply keep in mind the fact that whatever metal you wish to obtain the direct action of in its free state upon the tissue, whether it be zinc, copper, iron or any other metal, you connect it with the positive pole of the battery and obtain, when the current is completed, the free oxychlorid of the metal used.

First wipe out the uterine cavity carefully with some antiseptic, as listerine or aqueous sanitas, then pass in the copper electrode, having it insulated from the vagina. I much prefer to use the speculum in this work. Connect this copper electrode with the positive pole of the galvanic current, connect the negative pole with the large flat electrode that is placed over the abdomen; see that your connections are good, then turn on from three to ten cells, keeping your intra-uterine electrode moving, that is, do not allow it to remain stationary all the time during the treatment. In from two to five minutes you will observe a greenish tinge around the electrode. If there should be a very extensive catarrhal discharge you may not observe this greenish tinge until after the patient has received several treatments. Allow the current to pass for from eight to fifteen minutes, then turn off the

current and make a very careful attempt to remove the intra-uterine electrode. If you find any difficulty whatever in removing the electrode do not make much tension on it, but reverse your current so that the electrode is attached to the negative pole, allow the current to pass from two to three minutes, using from three to five cells, then you will find that the electrode will quickly loosen and slip out without any trouble and without any effort. These treatments should be given from once a week to three times a week. It is surprising how quickly some of those old cases will yield to this method of treatment. I have found in some cases where there was a badly diseased endometrium and curetting was objected to, that by first using a zinc intra-uterine electrode and afterwards wiping the uterine cavity out carefully with iodin and carbolic acid (95 per cent.) equal parts, and after a few treatments of this nature changing the zinc for the copper intra-uterine electrode, that the result was as good as though I had curetted.

I have had no experience in the use of this method in nose and throat work, but have seen some of the results which are very good in those cases where the treatment was indicated as has already been pointed out. Many times in the treatment of uterine fibroids where the endometrium is in a particularly bad condition, and even after curetting has been done, the use of the copper electrode in the manner described will be of great service in controlling hemorrhage and getting the endometrium in a healthy condition.

There is undoubtedly much to do in this line of work with the galvanic current, and I am sure that future years will show much improvement in the method of employing the chemical action of the current on human tissue.

CHAPTER XXIX.

Electro-Cautery.

There remains for us to consider electricity in its application to surgery, or, as it is generally called, electro-cautery.

You will remember that in the study of physics I called your attention to the fact that for electro-therapeutical work it was electro-motive force that was required. To obtain this we connected our cells in such a manner that the zinc of one cell was connected to the carbon of another, thus obtaining the desired result.

For cautery work it is not electro-motive force that is desired but quantity. Quantity, you will remember, is the amount of electricity passing through a circuit in a given time. To obtain this the cells are connected differently than when we wish to obtain electro-motive force. All the zincs are connected and all the carbons are connected.

There are a number of different cautery batteries on the market. Until within a few years the most commonly used and the most satisfactory for cautery purposes was the plunge battery.

You will observe from the drawing (Fig. 127) that there are a number of large zinc plates which are immersed in a strong acid solution. The electricity is set free at the zincs and collected upon the carbon plates. At one side is a rubber bulb which is connected with a rubber tube. When you wish to use this battery, the zinc and copper plates are dropped into the acid solution and the assistant, by squeezing the rubber bulb, prevents the collection of hydrogen bubbles upon the plates, thus keeping the cell from becoming polarized. Some of the plunge batteries have the plates

balanced in such a manner that, while the battery is in use, they may be kept rocking, and in this way prevent polarization.

As soon as you are through using the battery, lift the plates out of the solution, for they are destroyed very rapidly.

The objections to this battery are:

1st. Its size.

2d. It, being an acid solution, should be recharged each time before using, although it may do without this.

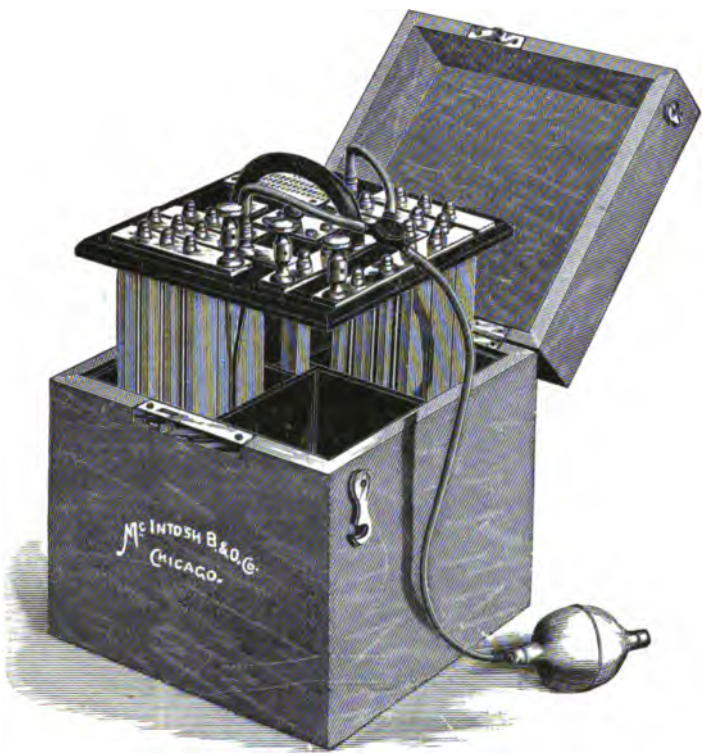

FIG. 127.

The dynamo, which has been already explained, is now being used to some extent for cautery purposes. However, it is not wholly satisfactory; but in the future it will be made so, no doubt.

At present the most popular and satisfactory battery for cautery

work is what is known as the storage battery. These batteries are made in various sizes and are charged.

The storage battery is not properly a storage battery. It is a cell composed of lead sheets insulated from each other and covered with a paste. This cell is connected to an incandescent-light wire,

FIG. 128.

or to gravity cells, and charged. The electricity sets up an action on the plates and they give out a current. They are connected, with a rheostat (Figure 128), by means of which the strength of the current is regulated.

FIG. 129.

These storage cells are of different makes and the directions for charging accompany them.

Fig. 129 is a combined faradic circuit and cautery.

For cautery work your conducting cords should be large and well protected. The most of the work is done with a snare, such as shown in Figure 130.

As you will observe, it is a piece of fine platinum wire passing through guides and so arranged that it can be steadily tightened;

FIG. 130.

and the handles provided with a button which, when pressed, completes the circuit.

Remember this in the use of these snares, do not put too much tension upon your platinum wire.

There are various styles of these electrodes (Fig. 131) for various purposes.

They are useful in removing portions of the uvula, tonsils, polypus from the nose or posterior nares, removing turbinated bones, etc.

In gynecology electro-cautery is useful in removing polypi, small fibroids that are located in the cervical canal, or just within the internal os. One of the most useful applications of the cautery is in the amputation of the cervix, either where there is a malignant condition, or where from unnatural length it becomes necessary to remove a portion of it.

Let a description of the manner of using the cautery for the amputation of the cervix suffice as a general description.

Fill your battery with a fresh solution; connect the cords to the binding posts, being sure the connections are clean and bright; put the wire in your snare, being particular to have this wire not too long; connect the snare with your cords and let your plates down into the solution. Of course if you have a storage battery this is not necessary. As has been said, nearly all storage batteries are provided with a rheostat, with which you switch on your current. If you have a storage battery, connect it up in the same way, press the button completing the circuit and test your battery. If the battery is in good working order the wire will soon become hot; shutting off the current you are ready to adjust the snare.

With your patient on her back well down to the edge of the table, the Sim's speculum introduced, take a firm hold of the cervix with a vulsellum. Draw the uterus well down if it is movable,

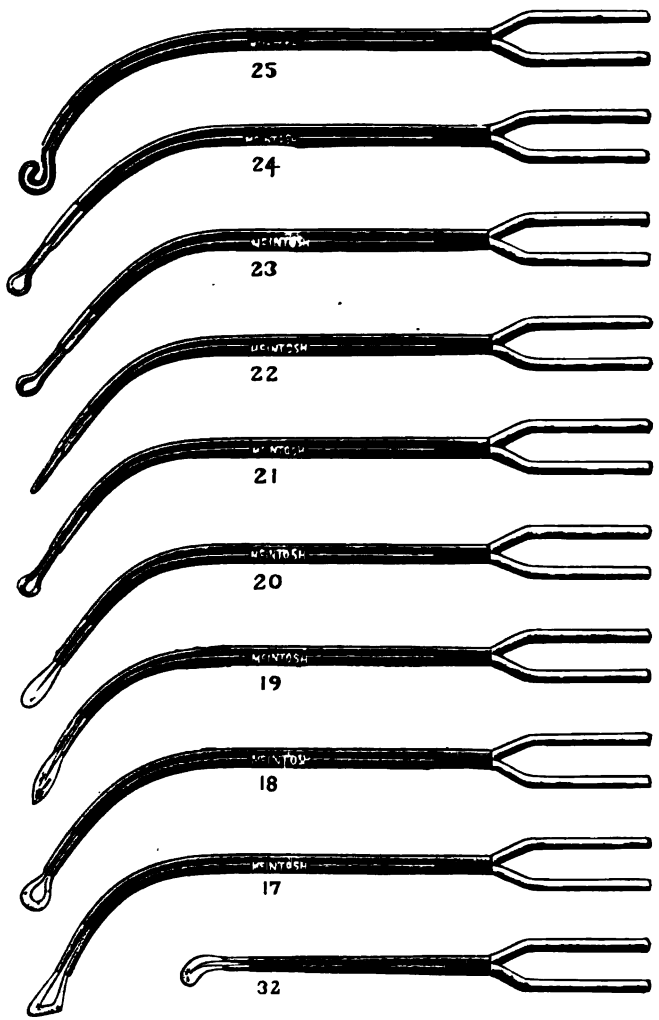

FIG. 181.

and slip the loop of the wire over the vulsellum. Pass the wire around the cervix as high up as desired, carefully adjusting it and making it tight. Now switch on the current, gradually at first and

stronger by degrees, keeping your platinum wire taut but not tight, and you will soon remove the cervix. If your battery is in good working order the cervix will be quickly amputated without any hemorrhage. Of course you will use an anesthetic for this purpose and have everything you use thoroughly antiseptic.

Let me say a few words in regard to the removal of hairs and moles. The removal of hair does not require a cautery battery; two or three cells of an ordinary office battery being sufficient for the purpose. An ordinary steel needle will answer for this work, but the needles that are prepared for this purpose are preferable. Connect the needle to the negative pole of your battery and place the other sponge electrode near the hair to be removed; pick up a hair with a pair of fine tweezers, and while you hold it taut, making no tension on it, pass the needle down into the hair follicle and in a few seconds the hair will loosen and slip out. Move the needle around in the hair follicle a few seconds, then withdraw it. In this way remove a few hairs, but do not pick them all out of one spot, for if you should you might have considerable inflammation. In a few days remove some more in the same manner.

For the removal of moles or nevi, pass the needle through the mole at its base and connect with it the negative pole, using from six to eight cells of the galvanic current. Place the other electrode near the mole; in a moment or so withdraw the needle and pass it at right angles. One or two applications of this kind will cause the mole to shrivel and disappear.

There are many uses to which electro-cautery may be put that I have not mentioned. With a platinum electrode made for the purpose the interior of the uterus may be cauterized. With a cautery knife cancerous and other tumors may be removed from any locality.

I have only briefly given you a few hints in this department. Those of you who wish to make yourselves more familiar with it will find valuable suggestions in Beard and Rockwell's work on electro-therapeutics.

Do not for a moment imagine that we have completed electro-

therapeutics as a study; we are only just beginning to know a few of the uses to which electricity may be put.

As I told you in the beginning, it is not a cure-all for all the aches and ailments to which the human body is heir; but it is a stimulant, a tonic and a sedative, and it is indicated as an adjunct in the treatment of any condition where either of these is required.

Let me insist again that if you are to be successful in your work with electricity, you must make yourselves familiar with its physics.

There has been no attempt to give you a scientific arrangement of facts, but to simply give you sufficient for the intelligent use of this remedy.

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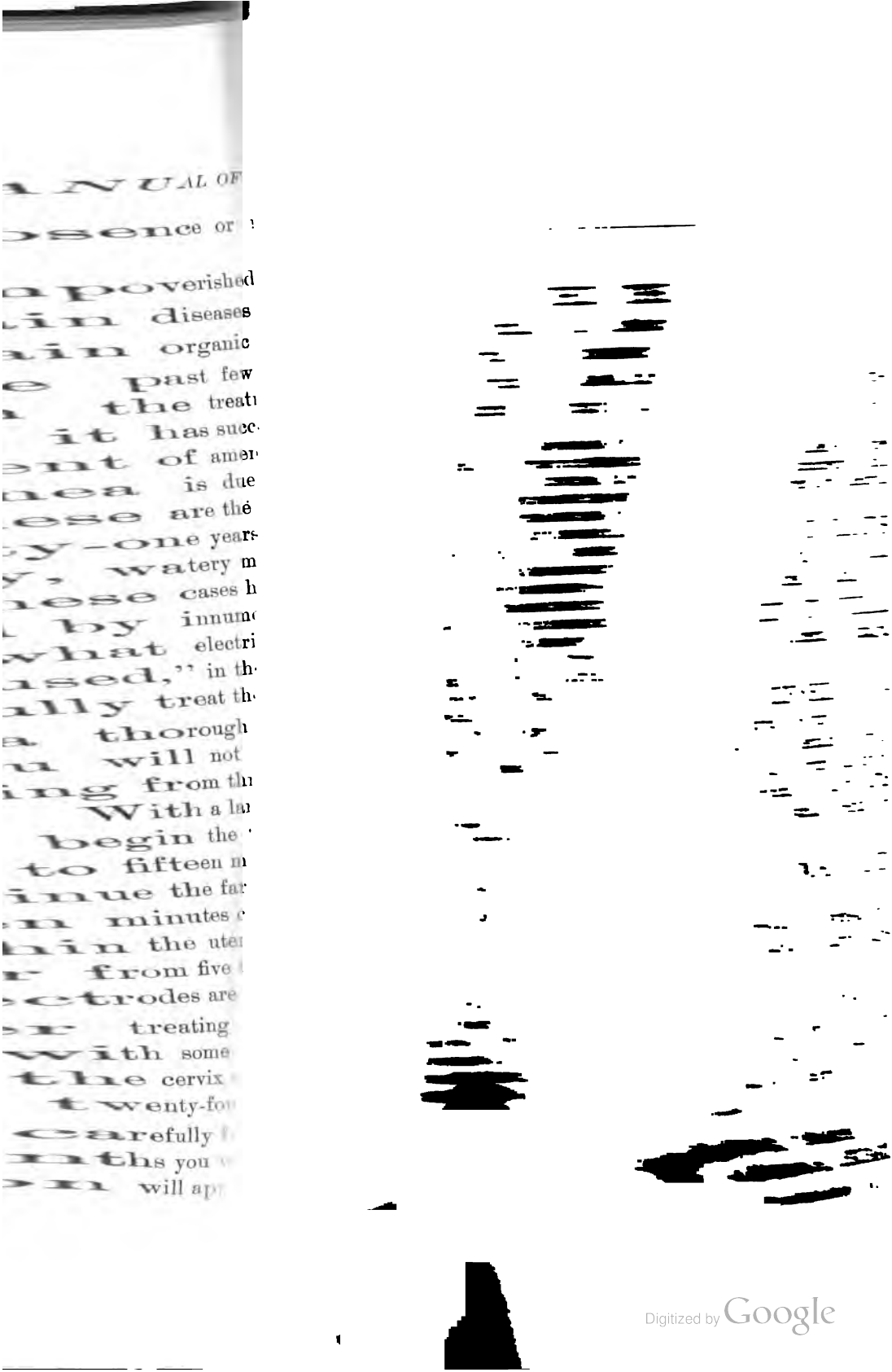

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